WASH Field Report No. 410

WATER QUALITY PRE-INVESTMENT STUDIES IN THE ARGES BASIN IN ROMANIA

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by

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PREFACE

The three members of the team that prepared the Yantra and Arges basin reports are Max Clark, team leader; David Laredo, financial specialist; and Bill Hogrewe, industrial wastewater specialist. Visits were made to Romania in October 1992, and in February, April, and May of 1993. Previous reports include the *Initial Assessment Report* (submitted October 31, 1992), the *Interim Basin Report* (February 27, 1993), and the *Prefeasibility Studies* (April 20, 1993).

Local support and technical assistance to the WASH team was provided under a WASH subcontract by Inginerie Urbana S.A. of Bucharest. Funding and coordination of the four WASH pre-investment studies were provided by the Europe Bureau of USAID.

Within the Arges basin in Romania, the WASH studies were carried out in coordination with other USAID projects, including the ETP (Environmental Training Project) and the industrial waste minimization program being executed by the WEC (World Environment Center).

The purpose of this report is to summarize and refine the previous reports, including the identification of water pollution control problems and possible solutions for three communities in the Arges basin: Pitesti, Cîmpulung, and Curtea de Arges. In cooperation with local and national pollution control officials, these communities were selected as the high-priority sites for WASH prefeasibility studies within the Arges basin. The projects identified would protect the surface water and bank-filtered sources of drinking water in downstream communities, including Bucharest, Pitesti, Mioveni, and Gaiesti.

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ACRONYMS

A.I.D.	U.S. Agency for International Development (Washington)
A.I.D./EUR/DR/ENR	A.I.D.'s Bureau for Europe, Office of Development Resources, Environment and Natural Resources
BOD_5	biochemical oxygen demand exerted in five days
COD	chemical oxygen demand
DEMDESS	Danube Emissions Management Decision Support System
EBRD	European Bank for Reconstruction and Development
EC	European Community
EIB	European Investment Bank
EPA	Environmental Protection Agency (U.S.)
EPDRB	Environmental Program for the Danube River Basin
IBRD	International Bank for Reconstruction and Development (division of the World Bank)
ICIM	Research and Engineering Institute for Environment
NGO	nongovernmental organization
O&M	operation and maintenance
PCU	Program Coordination Unit
PROED	Studies and Design Institute for Public Works
RENEL	National Autonomous Power Authority
RGAB	Bucharest water supply authority
TSS	total suspended solids
UNDP	United Nations Development Programme
UNEP	United Nations Environment Programme
USAID	U.S. Agency for International Development (overseas mission)
WASH	Water and Sanitation for Health Project
WEC	World Environment Center
WS&W	water supply and wastewater
WWTP	wastewater treatment plant

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UNITS

cmd	cubic meters per day
cu m	cubic meters
g	grams
ha	hectares
kg	kilograms
km	kilometers
L	liters
leu	Romanian currency (600 lei = $US 1 as of April 1993)
mg	milligrams
s	second(s)
sq km	square kilometers
T	metric tons

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EXECUTIVE SUMMARY

Project Outline

This basin report was prepared by a three-member USAID WASH team, based on its visits to Romania in October 1992, and in February, April, and May 1993. Previous reports include the *Initial Assessment Report* (submitted on October 31, 1992), the *Interim Basin Report* (February 27, 1993), and *Prefeasibility Studies* (April 20, 1993). This basin report describes one of four pre-investment studies WASH has prepared on four river basins tributary to the Danube River: the Yantra basin in Bulgaria, the Sajo-Hernad basin in Hungary, the Arges basin in Romania, and the Hornad basin in Slovakia. The purpose of the studies is to identify wastewater pollution control projects for municipalities and industries within the aforementioned Danube River basins. Local support and technical assistance to the WASH team were provided by Inginerie Urbana S.A. of Bucharest. Funding and coordination of the four WASH pre-investment studies were provided by the Europe Bureau of USAID.

The purpose of this report is as follows:

- To summarize and refine the results of the previous interim reports, including the identification of opportunities for investment and technical assistance by international lenders and donors.
- To describe the water pollution control problems and possible solutions for three communities in the Arges basin: Pitesti, Cîmpulung, and Curtea de Arges.

  In cooperation with local and national pollution control officials, these communities were selected as the high-priority sites for WASH prefeasibility studies within the Arges basin.
- To define phased prioritized programs or strategic plans for wastewater facilities rehabilitation and development within the three aforementioned communities, including wastewater collection, conveyance, municipal treatment, and industrial pretreatment to solve the communities' major water pollution control problems.
- To provide a preliminary estimate of costs, and to assess financial and institutional implications of implementing the aforementioned strategic plans.

Findings

<u>Background</u>

The Arges River basin includes Bucharest, the capital of Romania, (population 2.1 million), followed in size by the three municipalities of Pitesti (population 174,190), Cîmpulung (43,390), and Curtea de Arges (33,550). The total population of the basin is about 4 million, of which 2.5 million are urban.

Industry provides about half of total employment in the basin, with Bucharest alone accounting for an estimated 18 percent of national production. Industry also dominates economic activity in the three smaller municipalities, and in Oltenita at the mouth of the Arges on the Danube.

Principal features of the basin are shown in Figure 1. Many water-resources control projects have been developed for hydropower, water supply, irrigation, and flood control; as a result, stream flows in the basin are highly regulated and controlled. An estimated 90 to 95 percent of the urban population is served by public water supply systems, but approximately 1 million people in rural areas are served by private shallow wells in the shallow aquifer.

Public health statistics indicate low infant mortality and a low incidence of gastrointestinal disease; a relatively high incidence of hepatitis could be partly attributed to exposure to wastewater.

The average annual stream flow of the Arges River is about 65 cubic meters per second (cu m/sec or m^3/s), but large seasonal and yearly variations occur. Under drought conditions, the stream flows available for dilution and assimilation of wastes are limited. The natural low stream flow normally stipulated for use in pollution control planning (the minimum monthly flow exceeded in 95 percent of the years) is about 900,000 cmd, which is less than the known point-source wastewater discharges of about 2.1 million cubic meters per day (cmd) within the Arges basin.

Reservoirs in the mountains augment the natural stream flows. At the Ogrezeni water supply intake on the Arges River serving Bucharest, the regulated stream flow is about 1.2 million cmd, while the known wastewater discharges upstream from Ogrezeni amount to 300,000 cmd.

Stream water quality

The quality in 3,600 km of streams in the Arges basin is classified as follows: 35 percent in Category I (drinking water); 29 percent in Category II (water contact recreation and fishing); 14 percent in Category III (irrigation and industry); and 22 percent degraded (not meeting the quality standards for Category III).

Industries place a significant burden on surface water quality in the basin by discharging organics and nutrients into the municipal systems as well as directly to the rivers. Pollution is worst in the Dîmbovita River after the discharge of untreated wastewater from Bucharest, and in the Dîmbovnic river after the discharge of industrial wastewater effluent from the Arpechim petrochemical complex near Pitesti. Additionally, organic pollution from Curtea de Arges is causing eutrophication in the water supply reservoirs serving Pitesti, and the Bucharest water supply intake at Ogrezeni is affected by eutrophication caused by organic pollution from Pitesti, Cîmpulung, and Curtea de Arges.

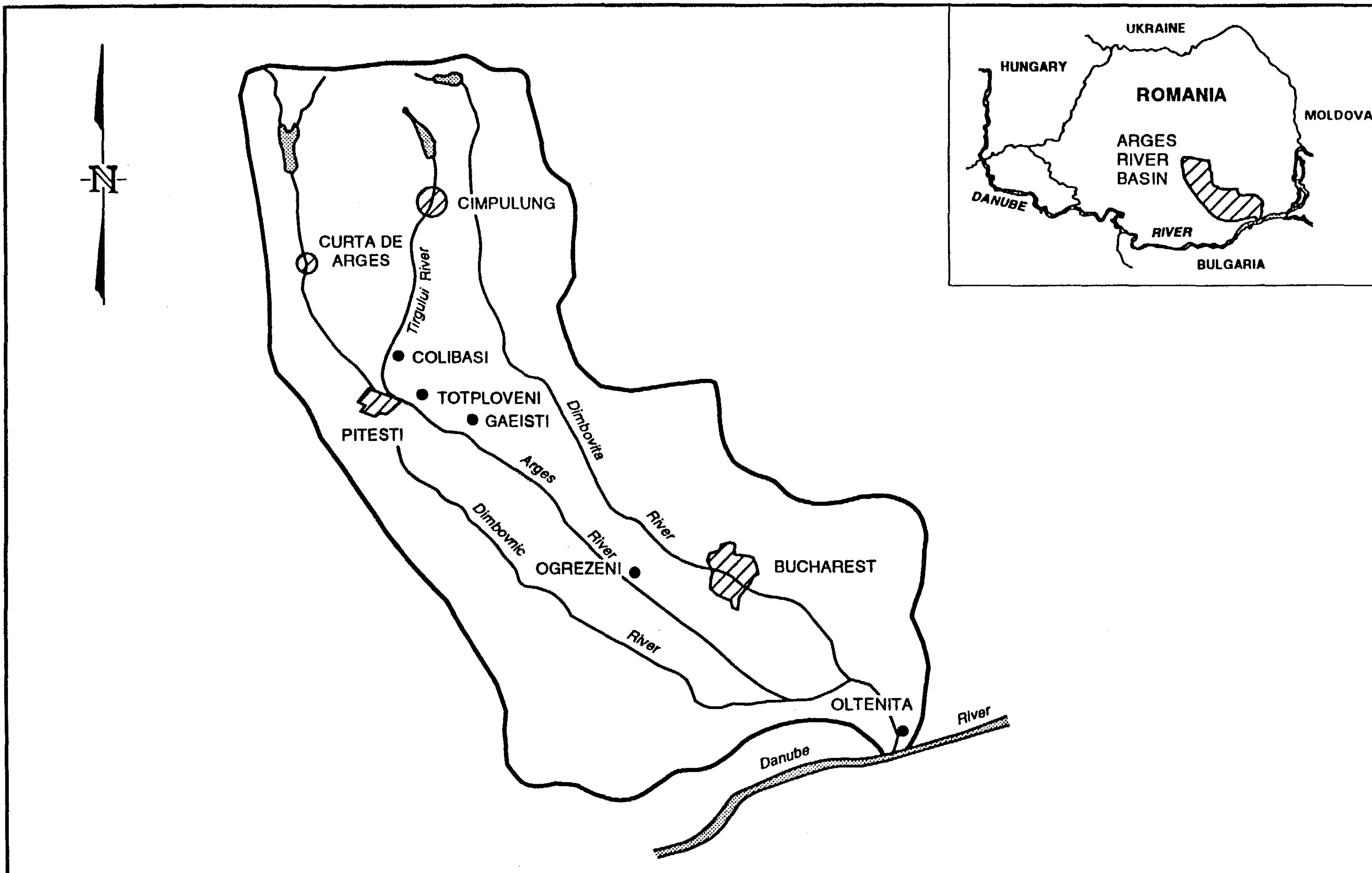

Figure 1
Map of the Arges Basin Study Area

An extensive amount of water-quality data was collected by the environmental inspectorate in Pitesti during 1992: 7,630 values for 32 water-quality parameters at 32 monitoring stations.The data indicate that ammonia levels exceeded the Category I standard of 0.1 mg/L in essentially all samples. Organic pollution (BOD and COD) is seasonally high, but dissolved-oxygen levels are generally good, except in the Dîmbovnic River and the lower reaches of the Dîmbovita and Arges. Testing for heavy metals, toxins, and pesticides has not been extensive, and therefore no conclusions on their existence or prevalence in streams can be made, aside from the known emissions of heavy metals from certain industries.

Nitrate levels are sufficiently high throughout much of the basin to support algae growth and occasional algae blooms. Phosphate and other forms of phosphorus appear to be the limiting nutrients for algae growth, rather than forms of carbon or nitrogen; reduction in phosphorus emissions from industry and municipalities should therefore be a priority to reduce eutrophication.

Groundwater quality

Deep, confined aquifers having good water quality have been developed for water supplies for Bucharest, Gaiesti, Colibasi, Topoloveni, and various industries. However, an estimated 1 million people in rural areas use shallow hand-dug wells in the surface (or phreatic) aquifer, which is usually contaminated by nitrates, often in the range of 50 to 300 mg/L.

Based on the results of a monthly sampling program covering 99 wells in the phreatic aquifer within the are of the Danube plain downstream from Pitesti, drinking water limits for nitrates, COD, and phosphates are frequently exceeded. The levels of chlorides, sulfates, ammonia, phenols, and total dissolved solids also are too high in certain locations, due to local pollution sources.

Although not a focus of this report, the need is apparent for a rural water supply project to provide water from the deeper aquifers.

Groundwater infiltration to rivers within the Danube plain is apparently negligible, and thus the concentrations of pollutants in groundwater do not affect the feasibility of projects to reduce eutrophication and surface water pollution.

Wastewater emissions

Data for 1991 on wastewater flow are available for 400 dischargers in the Arges basin, and data for 1992 on wastewater flow and quality are available for 72 major dischargers. The total municipal wastewater discharge in the area is about 2 million cmd, of which Bucharest accounts for 88 percent. Pitesti, Cîmpulung, and Curtea de Arges account for an additional 10 percent. The largest treated effluent is 156,000 cmd from the secondary treatment plant at Pitesti, while Cîmpulung and Curtea de Arges each produce 22,000 cmd of secondary treated effluent. Six smaller plants provide primary or secondary treatment to a flow of 35,000 cmd. Within the four largest municipalities, industry produces about half of the municipal wastewater. In general the effluent from the municipal treatment plants is of poor quality, and contains excessive amounts of organic pollution (BOD, phosphates, ammonia, and nitrates), which indicate substandard operation, insufficient capacity, or incomplete construction of facilities.

Direct industrial discharges to rivers amount to 183,000 cmd from 62 industries, of which the largest flows are from the Arpechim petrochemical complex (120,000 cmd), the Dacia car factory in Colibasi (24,000 cmd), the SC ROLAST rubber plant in Pitesti (7,700 cmd), the SC ALPROM wood products plant in Pitesti (5,100 cmd), and the Aro car factory in Cîmpulung (4,900 cmd). Many of the industrial wastewater treatment facilities are aging, overloaded, and in need of major upgrading or repair, although the expertise for operation is available. The potential risk is large for spills and upsets of pretreatment processes. The storage of spent plating baths (particularly at the car factories) and inadequate disposal of metal-containing sludges increase the probability of uncontrolled discharges of metals and cyanides into waterways and municipal wastewater systems.

Protection of the Bucharest water supply intake at Ogrezeni against algae blooms will most probably require a reduction in phosphate emissions. Of the total phosphate emissions of 160 kg/day upstream from Ogrezeni, about 90 kg/day are from municipal plants in Pitesti, Cîmpulung, and Curtea de Arges. The Dacia car factory and the neighboring Colibasi municipal plant account for an additional 49 kg/day.

Phosphates can be consumed and settle out in reservoirs on the Arges before reaching Ogrezeni, which could mask the effect of other large sources of phosphates from agricultural runoff or feedlots. However, it is significant that the known point-source emissions are large compared with the average phosphate load measured in the Arges River near Ogrezeni of about 100 kg/day during 1992.

Institutional and financial conditions

Although legislation on water pollution control in Romania was first enacted in 1973, rapid changes have occurred since 1989 and are ongoing. The country's Ministry of Environment was established in 1991 with broad jurisdiction for environmental management; it has now been incorporated into the Ministry of Waters, Forests, and Environmental Protection. The new ministry includes Apele Romane (the Romanian Waters Authority), which is responsible for water resources management, including water quality. Adoption of a new environmental law is expected by mid-1993, and a new water law is in preparation. The new water law would establish 14 river basin authorities (including the Arges basin), which would impose charges for raw water extractions and collect fees and fines for discharging wastewater.

The environmental inspectorate in Pitesti monitors and tests the quality of streams and wastewater emissions, grants discharge permits, and reviews environmental assessments of proposed projects. The Arges River Basin Water Authority is financially self-sufficient from tariffs on water supplies and fines on excessive withdrawals, or wastewater discharges that exceed quality standards; under the planned legislation, the water authority will become a semi-autonomous operating agency. Currently, tariffs and fines are too low to bring about improved pollution control by industries (for example, to prevent brine discharges from excessive use of water in oil-recovery operations).

Municipal enterprises operate the area's municipal wastewater treatment plants, as well as providing water supply, heat, hot water, and solid-waste collection. The municipal enterprises are financially self-sufficient, but revenues are only enough to cover operation and maintenance costs. Under current circumstances, the enterprises are expected to raise sufficient revenues to cover capital investments in improved treatment facilities, but it is apparent that domestic and industrial customers cannot afford to repay significant capital investments. The municipalities seldom impose fines on excessive pollution by industry, even though they themselves are required to pay fines to the river basin authority.

In general, sources of financing for wastewater treatment projects in the Arges basin in Romania are extremely limited. Industrial production has declined substantially since 1989, and industries are in too precarious an economic position to finance improved wastewater treatment. Capital funds for municipal works, formerly obtained from the central government, are very limited. At the recent rapid rates of inflation, municipal tariffs cannot keep pace to cover increased labor and materials costs, let alone provide funds for improvements. Current interest rates of 70 percent per year preclude local long-term borrowing, and could block the on-loaning of funds borrowed by the central government from international donors (unless the donors make an exception to their usual requirements). An environmental fund is to be established under the draft water law, but until taxes, fees, and fines can be legally assessed and retained at the local level, self-financing by municipalities will not provide sufficient funds.

Priorities for wastewater treatment

Completion of the Bucharest wastewater treatment plant and improved treatment for the Arpechim petrochemical complex are obvious high-priority needs to improve environmental conditions in the Arges basin and the Danube, but they are being studied by other parties; therefore, WASH did not conduct prefeasibility studies of these problems. Specifically, central government funding of the Bucharest plant has continued despite current economic conditions, and a related World Bank-sponsored water and wastewater planning study is about to begin. Treatment problems at Arpechim have been studied by Romania's Research and Engineering Institute for Environment (ICIM), and technical assistance in waste minimization is to be sponsored by USAID. Other USAID-sponsored studies are also under way to determine which refineries are the most efficient in Eastern Europe and should be retained. Production at Arpechim was at 60 percent of capacity in February 1992, and at 30 percent of capacity in October 1992; thus, it would be risky to build improved treatment facilities in the near term.

Improved wastewater treatment plants in Pitesti, Cîmpulung, and Curtea de Arges to protect the water supplies for Bucharest and Pitesti are the next-highest priority projects in the basin. The Dacia car factory in Colibasi contributes to eutrophication and possible heavy metals (due to chemical spills) that affect water supplies, but it has the expertise and revenues to improve its treatment without foreign technical assistance or loans. Other contributors to pollution in the upper Arges basin, such as the municipalities of Colibasi and Topoloveni, are small in

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comparison. As a result, and in consultation with local and ministry officials, it was concluded that the WASH prefeasibility studies should encompass the wastewater management needs of the three municipalities of Pitesti, Cîmpulung, and Curtea de Arges.

Additional program elements

Other opportunities for technical assistance or loans by international donors or lenders include the following:

- DEMDESS assistance: The Danube Emissions Management Decision Support System (DEMDESS) software and database capabilities developed by WASH should be supported, so that Romania can continue to cooperate effectively with other Danubian countries. Assistance would include adding user-friendly elements to the software for its use by decision-makers and training of users both at the ministry and the Arges environmental inspectorate in Pitesti.

- Environmental management training and assistance: Under Romania's new environmental and water laws, decentralization of responsibilities to the local level will occur, including a new, strengthened Arges River basin authority and a new environmental inspectorate that will have responsibility for all media (water, land, and air) and for developing and reviewing environmental impact statements. Assistance should be provided to define appropriate national and river-basin organizational and managerial responsibilities and roles; activities and procedures; staff training and personnel qualifications; and laboratory equipment, transportation, and communications requirements.

- Rural water supply: Approximately 1 million people supplied from the polluted surface aquifer should instead be served by rural water systems supplied from deeper, confined aquifers.

- River basin water-quality master plan: Many technical, institutional, financial, and organizational issues require further study and broader input, including the development of a politically acceptable method of waste load allocation, and the development of a phased financing and implementation plan that will be affordable to users.

- Arpechim wastewater facilities plan: Should the petrochemical complex be judged economically viable (a decision expected within the next six months), its treatment requirements could be considered in combination with modernization of the complex's production facilities.

- Heavy-metals recovery plant: The Aro and Dacia car plants cannot safely dispose of their metal-containing sludges, but their sludge could be processed and heavy metals recovered and recycled. The cost of the plant could be funded under a grant to introduce modern industrial treatment technology.

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- Studies on solid wastes and hazardous wastes: Identification of suitable sites for sanitary landfills and provision of appropriate equipment for collection, hauling, processing, and disposal of solid and hazardous wastes are needed.

- Institutional development: Training of municipal and industrial treatment plant operators and modest investments in laboratory and operations equipment could provide immediate improvements in stream quality at low cost, and provide more details on what is needed to rehabilitate existing plants. The municipalities need exposure to the methods of municipal finance, organization, and management that have proven successful in other democratic free-market countries.

Prefeasibility Studies

Service areas and projected flows

Possible changes in the limits of the existing service areas for the three municipal treatment plants have been considered, primarily for the Pitesti plant. It has been concluded, however, that for economic, technical, and political reasons, the existing service areas should not be greatly enlarged, except to accommodate expected increases in population.

Two planning horizons for flow and population projections have been adopted herein: the year 2000 for Phase I improvements and the year 2010 for Phase II improvements. In addition, immediate improvements have been defined. Expansion in capacity in two construction stages (to treat the projected flows in the years 2000 and 2010, respectively) have been considered in certain instances to minimize initial capital costs and the total present-worth economic cost. Previous studies and readily available data have been used in the projections of population and wastewater flow, which are summarized in Table 1.

Service coverage

Flow and cost allowances have been made to extend local sewerage systems on pace with population growth, such that 95 percent of the population of Pitesti will be served by the year 2010, along with 90 percent of the populations of Cîmpulung and Curtea de Arges. Industrial production has been assumed to recover and resume its long-term growth trend by the year 2000. In the year 2010, industrial flows will account for about one-third of the total projected flow at the Pitesti and Curtea de Arges plants, and one-half of the total at the Cîmpulung plant. Also by 2010, infiltration will account for 20 to 30 percent of total flow at Pitesti and Curtea de Arges; no estimates have been made for infiltration at Cîmpulung through the year 2010.

Per capita flow allowances, including unmetered public use for hot water and heat, are high (typically 400 to 500 liters per capita per day) compared with those for domestic use in Western countries. These high flow allowances for domestic use have been retained because of the major costs and difficulties expected in changing from the present system of metering

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water for blocks of apartment buildings to a system in which customers in individual apartments would be metered and billed for both cold and hot water.

Table 1

Population and Wastewater Flow Projections, Arges Prefeasibility Studies

	1993	2000*	2010*
		Total Population	
Pitesti	201,500	245,000	285,000
Cîmpulung	48,700	54,900	60,600
Curtea de Arges	35,800	43,700	48,300
		Total Wastewater Flow (cmd)	
Pitesti	156,000	254,000	300,000
Cîmpulung	22,300	28,000	38,000
Curtea de Arges	24,200	33,000	43,000

*Estimated

Components of the strategic plan

Capital investments required in the immediate phase, Phase I, and Phase II have been estimated for the facilities required, which include extension of sewerage systems; inspection via remote camera and rehabilitation of sewers to reduce groundwater infiltration; rehabilitation and expansion of existing secondary treatment plants; major rehabilitation and improvement in sludge processing; and, in the case of Pitesti, the provision of nitrification/denitrification treatment processes by the year 2000. Reduction of phosphates in the treated effluent from Cîmpulung and Curtea de Arges would be accomplished primarily by improving the operation of secondary treatment facilities. The components of the proposed improvements for the three communities are itemized in Tables 2, 3, and 4.

Table 2

Pitesti Municipal Wastewater Facilities—
Summary of Strategic Plan

Investment Description	When Needed	Flow or Condition Covered	Cost[a]		Comments
			Million Lei	Thousand Dollars[b]	
A) Immediate					
1) Improve existing sewer system.	Immediately	Existing flow = 156,000 cmd	60	100	Covers inspection of, smoke tests of, and repairs to the parts of the existing sewers that are in very poor condition.
2) Optimize O&M operations at WWTP. Improve WWTP laboratory.	Immediately	Existing flow = 156,000 cmd	90	150	Optimize plant O&M to improve phosphorous removal. Improve laboratory capabilities and municipal enterprise operations to detect and control industrial sources of phosphorous and nitrogen.
3) Rehabilitate mechanical and electrical equipment at existing WWTP.	Immediately	Existing flow = 156,000 cmd	1,800	3,000	Much of the equipment at the existing plant is old and poorly maintained. A large portion of the mechanical and electrical equipment must be replaced for the process to operate efficiently.
4) Expand preliminary treatment.	Immediately	Existing flow = 156,000 cmd	120	200	The existing preliminary treatment capacity is only 127,000 cmd. Add 63,000 cmd preliminary treatment capacity to match total plant capacity of 190,000 cmd.
B) Phase I					
5) Sewer additions.	Year 2000	Existing flow + 98,000 cmd total = 254,000 cmd	270	450	Add new sewers to serve an additional 42,000 persons.
6) Primary, secondary, and sludge digestion additions.	Year 2000	Existing flow + 98,000 cmd total = 254,000 cmd	2,880	4,800	Existing facilities should have a 190,000 cmd capacity when rehabilitated (item 3 above). Additional 64,000 cmd capacity includes primary treatment, secondary treatment, and sludge digestion added to existing WWTP.

(continued)

Table 2 (continued)

Investment Description	When Needed	Flow or Condition Covered	Cost[a]		Comments
			Million Lei	Thousand Dollars[b]	
7) Nitrification and denitrification and filter press additions.	Year 2000	Existing flow + 98,000 cmd total = 254,000 cmd	7,200	12,000	Add nitrification, denitrification, and sludge filter press capacity for the full Phase I flow (254,000 cmd).
C) <u>Phase II</u>					
8) Primary, secondary, nitrification, denitrification, sludge digestion, and filter press additions.	Year 2010	Phase I + 46,000 cmd total = 300,000 cmd	3,700	6,150	Additional 46,000 cmd capacity includes primary treatment, secondary treatment, nitrification, denitrification, sludge digestion, and sludge filter press.
9) Sewer additions.	Year 2010	Phase I + 46,000 cmd total = 300,000 cmd	200	350	Add new sewers to serve an additional 38,000 persons.
<u>Summary</u>					
A) Immediate Costs: Items 1 - 4	Immediately	Existing flow = 156,000 cmd	2,070	3,450	
B) Phase I Costs: Items 5 - 7	Year 2000	254,000 cmd	10,350	17,250	
C) Phase II Costs: Items 8-9	Year 2010	300,000 cmd	3,900	6,500	
		TOTAL	16,320	27,200	

[a] Costs represent 1993 Romanian market costs and include 20 percent for contingencies.
[b] Exchange rate of 600 lei/$US 1.

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Table 3

Cîmpulung Municipal Wastewater Facilities—
Summary of Strategic Plan

Investment Description	When Needed	Flow or Condition Covered	Cost[a]		Comments
			Million Lei	Thousand Dollars[b]	
A) <u>Immediate</u>					
1) Improve existing sewer system, WWTP laboratory, and O&M.	Immediately	Existing flow = 22,300 cmd	60	100	Covers the inspection of, smoke tests of, and repairs to existing sewers; laboratory upgrade; and O&M training needs.
2) Rehabilitate digester.	Immediately	Existing flow = 22,300 cmd	36	60	Rehabilitate existing digester's mechanical and electrical elements. Provide adequate capacity for one-third of 1993 flow.
3) Add new digester.	Immediately	Existing flow + 5,700 cmd total = 28,000 cmd	48	80	Additional capacity is needed for remaining two-thirds of 1993 flow (assuming item 2 above is completed). However, the additional cost to add capacity to accommodate total Phase II flow is small; therefore, size the digester for Phase II flow now.
4) Expand preliminary treatment.	Immediately	Existing flow + 15,700 cmd total = 38,000 cmd	58	97	Existing preliminary treatment is adequate for only 13,000 cmd. Therefore, 9,700 cmd capacity is needed to treat existing flows. However, the additional cost to add capacity to accommodate total Phase II flow (10,000 additional cmd) is small; therefore, size the plant for Phase II flow now.
B) <u>Phase I</u>					
5) Extend sewer system.	Year 2000	Existing flow + 5,700 cmd total = 28,000 cmd	36	60	Add new sewers to serve an additional 6,700 persons.

(continued)

Table 3 (continued)

Investment Description	When Needed	Flow or Condition Covered	Cost[a]		Comments
			Million Lei	Thousand Dollars[b]	
6) Add sludge thickeners.	Year 2000	Existing flow + 15,700 cmd total = 38,000 cmd	34	57	Existing thickener capacity is adequate for existing flow. Incremental cost to accommodate Phase I flow is only slightly less than to accommodate Phase II flow; therefore, size the thickeners for Phase II flow.
7) Add filter press.	Year 2000	Existing flow + 15,700 cmd total = 38,000 cmd	24	40	No existing filter press exists currently. Incremental cost to accommodate Phase I flow is only slightly less than to accommodate Phase II flow; therefore, size the press for Phase II flow.
C) Phase II					
8) Add aeration capacity.	Year 2010	Phase I + 10,000 cmd total = 38,000 cmd	104	174	Existing aeration capacity is adequate for Phase I flow (28,000 cmd). Add 10,000 cmd capacity to obtain Phase II flow (38,000 cmd).
Summary[c]					
A) Immediate Costs: Items 1 - 4	Immediately	Existing flow = 24,200 cmd	202	337	
B) Phase I Costs: Items 5 - 7	Year 2000	28,000 cmd	97	157	
C) Phase II Costs: Item 8	Year 2010	38,000 cmd	104	174	
		TOTAL	400	668	

[a] Costs represent 1993 Romanian market costs and include 20 percent for contingencies.

[b] Exchange rate of 600 lei/$US 1.

[c] No costs for nitrification/denitrification or phosphorus removal are shown. Strategy is to wait until year 2000 to determine if nutrient removal is needed at all. The assimilative capacity of the stream may be adequate to remove nutrients. Nitrification/denitrification for Phase I flow is estimated at 960 million lei or $US 1.6 million (1993 basis). Based on the magnitude of this cost versus the costs for the other improvements cited, it is logical to delay this expenditure until its need is established.

Table 4

Curtea de Arges Municipal Wastewater Facilities—
Summary of Strategic Plan

Investment Description	When Needed	Flow or Condition Covered	Cost[a]		Comments
			Million Lei	Thousand Dollars[b]	
A) Immediate					
1) Improve existing sewer system, WWTP laboratory, and O&M.	Immediately	Existing flow = 24,200 cmd	30	50	Covers the inspection of, smoke tests of, and repairs to existing sewers; laboratory upgrade; and O&M training needs.
2) Add preliminary treatment.	Immediately	Existing flow = 24,200 cmd	79	132	Add bar screens and grit removal to increase preliminary treatment capacity by 11,000 cmd to match capacity of plant as a whole.
3) Rehabilitate digester.	Immediately	Existing flow = 24,200 cmd	90	150	Repair or replace heating equipment in existing units.
4) Add aeration capacity and final settling tanks.	Immediately	Existing flow = 24,200 cmd	329	548	Use Bio-Protein treatment plant for added aeration capacity. Construct added clarifiers on part of sludge drying bed area. Costs include payment to purchase the Bio-Protein facilities; and yard piping, pumps, and clarifiers for half of total plant flow.
5) Sludge filter press.	Immediately	Existing + 9,000 cmd total = 33,200 cmd	324	540	Filter press is added for existing sludge production plus full Phase I capacity. Will free area of sludge drying beds to accommodate new clarifiers.
B) Phase I					
6) Extend sewer system.	Year 2000	Existing + 9,000 cmd total = 33,200 cmd	48	79	Add new sewers to serve an additional 8,800 persons.
7) Add new digesters.	Year 2000	Existing + 9,000 cmd total = 33,200 cmd	106	176	Add complete new digester to accommodate Phase I flow. Some Bio-Protein treatment plant digestion facilities may be used.
8) Add aeration capacity.	Year 2000	Existing + 9,000 cmd total = 33,200 cmd	0	0	No capital cost because Bio-Protein plant will provide sufficient aeration for full Phase I flow. Assume pumps and piping in item 4 above are adequate.

(continued)

Table 4 (continued)

Investment Description	When Needed	Flow or Condition Covered	Cost[a]		Comments
			Million Lei	Thousand Dollars[b]	
9) Add final clarifiers.	Year 2000	Existing + 9,000 cmd total = 33,200 cmd	203	339	Construct new secondary clarifiers. More land must be purchased.[c]
C) <u>Phase II</u>					
10) Extend sewer system.	Year 2010	Phase I + 10,000 cmd total = 43,200 cmd	54	90	Add new sewers to serve an additional 10,000 persons.
11) Add digester, filter press, and secondary clarifier additions.	Year 2010	Phase I + 10,000 cmd total = 43,200 cmd	510	851	Additional land is needed for clarifiers; it is assumed that adequate area exists for the digester and filter press.[c]
12) Add aeration equipment.	Year 2010	Phase I + 10,000 cmd total = 43,200 cmd	15	25	The Bio-Protein plant is assumed to have adequate aeration capacity. Capital costs are for additional pumps and piping.
<u>Summary</u>[d]					
A) Immediate Costs: Items 1 - 5	Immediately	Existing flow = 24,200 cmd	852	1,420	
B) Phase I Costs: Items 6 - 9	Year 2000	33,200 cmd	357	594	
C) Phase II Costs: Items 10 - 12	Year 2010	43,200 cmd	579	966	
		TOTAL	1,788	2,980	

[a] Costs represent 1993 Romanian market costs and include 20 percent for contingencies.
[b] Exchange rate of 600 lei/$US 1.
[c] Land cost included at current market estimates of $US 50,000 per hectare.
[d] No costs for nitrification, denitrification, or phosphorus removal are included; it is assumed that industrial waste minimization and improved municipal plant operation will be adequate for nutrient reduction.

Improvements in industrial wastewater pretreatment and in minimization of wastes created during industrial processing operations are also required. These improvements are needed in order to reduce the pollution loads on the municipal plants, to protect the biological treatment processes at the municipal plants from toxic industrial wastes, and to reduce heavy metals in the municipal sludge that might prevent the sludge's agricultural reuse. The primary requirements for the major industrial dischargers in Pitesti, Cîmpulung, and Curtea de Arges are summarized in Tables 5, 6, and 7.

Table 5

Industrial Pretreatment Requirements for Pitesti

Industry	Description	Flow Rate	Major Contaminants	Needs
Alprom	Wood products	4,320 cmd	BOD, 3,500 kg/day; nitrate, 15 kg/day; ammonia, 95 kg/day	- Waste minimization - BOD removal facilities - Nitrogen removal facilities
Rotan	Leather products	1,397 cmd	BOD, 485 kg/day; ammonia, 201 kg/day; phosphate, 6 kg/day	- Waste minimization - BOD removal facilities - Nitrogen removal facilities
Novatex	Textiles	4,320 cmd	Ammonia, 212 kg/day	- Waste minimization - Nitrogen removal facilities
Argesana	Textiles	3,456 cmd	COD, 4,285 kg/day	- Waste minimization
Divertex	Textiles	2,592 cmd	Phosphate, 12 kg/day	- Waste minimization - Phosphate removal facilities
Pitbere	Beer	259 cmd	Phosphate, 18 kg/day	- Waste minimization - Phosphate removal facilities

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Table 6

Industrial Pretreatment Requirements for Cîmpulung

Industry	Description	Flow Rate	Major Contaminant	Needs
Aro	Vehicle manufacture	8,640 cmd	Ammonia, 64 kg/day; phosphate; heavy metals	- Waste minimization - Nitrogen removal facilities - Phosphorus removal facilities - Additional metals removal - Effluent monitoring - Spill plan - Sludge management - Metals reclamation
Grulen	Synthetic fibers	2,458 cmd	Ammonia, 13 kg/day	- Waste minimization - Nitrogen removal facilities
Cherestea Voinesti	Wood products	260 cmd	Ammonia, 29 mg/L (low load)	- Minimal needs due to low contamination

Table 7

Industrial Pretreatment Requirements for Curtea de Arges

Industry	Description	Flow Rate	Major Contaminant	Needs
Abator Pasari	Chicken processing	691 cmd	Nitrogen compounds	- Waste minimization - Nitrogen removal facilities
Arpo	Porcelain	1,356 cmd	Ammonia, 19 kg/day	- Waste minimization - Nitrogen removal facilities
Electroarges	Electronics	2,160 cmd	Heavy metals, ammonia	- Waste minimization - Effluent monitoring - Additional metals removal
Icil	Dairy	259 cmd	BOD, 454 kg/day; nitrate, 29 kg/day	- Waste minimization - BOD removal - Nitrogen removal

Financial considerations

As shown in Tables 2, 3, and 4, the total capital cost for municipal wastewater facilities in the three towns is estimated as follows:

	Million $US	Billion Lei
Immediate improvements:	5.207	3.124
Phase I (1993-2000):	18.001	10.801
Phase II (2000-2010):	7.640	4.583
Totals	30.848	18.508

Of this total capital cost, an estimated 88 percent is needed for Pitesti, 10 percent for Curtea de Arges, and 2 percent for Cîmpulung.

Annual costs of operation and maintenance will increase above existing levels; these costs have been estimated using current prices for labor, electricity, and materials.

The primary financial concern is whether the domestic users of the wastewater systems can afford to pay for improvements to them. The impact on households in the three communities has been estimated based on an average current monthly household income of $US 47, or 27,763 lei, in urban areas, and the following conservative set of financial assumptions:

- No subsidy is available from the central government.
- A direct loan from an international donor to a municipality, repaid over 20 years, would be charged at an interest rate of 12 percent. The municipality would repay the loan in hard currency (if available), and thus would pay a much larger amount in inflated lei.
- Household incomes will remain constant to the year 2010, when computed in terms of the current purchasing values of the U.S. dollar and the Romanian leu. This is highly unlikely, because household incomes will rise substantially due to increased wages as government subsidies on housing, food, and many other consumer goods and services are reduced.
- Continued disparity will exist between the market foreign exchange rate and the actual economic quality of living in Romania. For example, current government subsidies in essence make the average household income in Romania 10 times its net value. As the country's economy moves closer to a true market economy, however, subsidies will, theoretically, be proportionately replaced by increased incomes.

- Cross-subsidies from industry will be eliminated. At present, industries pay a tariff that is five to seven times greater per cubic meter of wastewater than the tariff households pay. (The higher rate industries pay was set indiscriminately, and probably was chosen under the assumption that they can afford to pay more than household users can.) For the team's analysis, therefore, no cross-subsidy was assumed. If industrial tariffs were included at levels equal to one-half the existing industrial-to-domestic tariff ratio, the tariffs for domestic users would be lowered by about one-third to one-half the values shown.

In addition, using the available statistics, the impact on poorer households has been considered; the lowest one-third of households is estimated to earn less than 80 percent of the average wage.

The analysis of financial impact is summarized in Table 8, in terms of the percentage of household income required to pay for existing and improved wastewater service.

Table 8

Financial Impact of Wastewater Fees on Households

Time Period	**Pitesti**	**Cîmpulung**	**Curtea de Arges**
	Fees, in Percent of Income for Average-Income Households		
Existing conditions	1.3	0.6	1.0
Immediate improvements	2.7	1.3	4.3
Phase I (1993–2000)	7.4	1.5	4.7
Phase II (2000–2010)	7.9	1.6	5.1
	Fees, in Percent of Income for Low-Income Households		
Existing conditions	1.6	0.8	1.3
Immediate improvements	3.5	1.7	5.2
Phase I (1993–2000)	8.5	2.0	5.9
Phase II (2000–2010)	9.9	2.1	6.4

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At present, households in the three communities pay about 1 percent of their income for wastewater service. The percentages shown in Table 8 indicate that in Phase II, beginning in the year 2000, lower-income households would apparently pay up to approximately 10 percent of their income, or up to about 10 times the percentage of income they pay now. However, if public subsidies are eliminated, incomes should increase by 10 times. By this reasoning, households should be able to pay for improved wastewater service, if free-market, unsubsidized salaries and prices are achieved. Costs for industrial facilities have not been estimated at this prefeasibility level, since the wastewater flows and loads may change significantly as a result of waste minimization and industrial process changes.

Chapter 1

CONTEXT OF THE REPORT

1.1 Objectives of the Study

The objectives of the wastewater pre-investment study on the Arges River basin were to assess major sources of water pollution in the Arges basin; to develop a priority ranking of possible pollution control projects in accordance with criteria that include impacts on human health and the environment; and to prepare prefeasibility studies on high-priority projects suitable for consideration by potential donors and investors.

1.2 Background

The activities undertaken in this study build upon work completed during the past few years. In 1991-92, USAID provided funds to the USAID WASH Project to support the regional Environmental Program for the Danube River Basin (EPDRB) in four countries: Bulgaria, Slovakia, Hungary, and Romania. This program is also being supported by several other agencies: UNDP, UNEP, IBRD, EBRD, EIB, and the EC countries through a Program Coordination Unit (PCU) in Brussels. The program was jointly established by the riparian countries in Sofia in September 1991, in order to develop a strategic action plan for water pollution control and carry out institutional strengthening and human resource development activities during a three-year period.

The current WASH Danube pre-investment studies are an outgrowth of the first WASH Danube study, which accomplished three major tasks: (1) identification of high-priority, immediate investment needs to control municipal and industrial wastewater emissions, for which pre-investment studies might be funded by international donors and funding agencies; (2) an evaluation of institutional conditions and needs to support implementation of wastewater emission control programs; and (3) preparation of an initial computer-based system (DEMDESS, the Danube Emissions Management Decision Support System) and user manual for decision-makers to manage a broad range of types of data (point-source emissions and emitters, river water quality, stream flows, emission standards, stream classifications, treatment options, costs, user fees, fines, taxes, water-quality modeling, and institutional data).

A three-volume report on point-source emissions in the Danube and a user manual summarize the results of the 1991-92 WASH Danube study (*Point Source Pollution in the Danube Basin*, WASH Field Report No. 374). The findings and conclusions from the report have been used by funding agencies to identify river basins and potential high-priority projects for pre-investment studies. DEMDESS software and databases have been developed and applied to pilot basins in the four countries, including the Arges basin in Romania.

A scope of work similar to that for the Arges basin study is being used by other donors in other basins in Romania. These studies cover the Olt basin (funded by IBRD of the World Bank) and the Siret basin (funded by EBRD).

1.3 Organization and Methodology of the Study

The Ministry of Waters, Forests, and Environmental Protection supported the Arges pre-investment study in several ways. Officials of the Department of Waters and Apele Romane (the Romanian Waters Authority), and the Department of Environment participated in discussions on prioritizing pollution-control projects in the Arges. Additionally, the regional environmental inspectorate in Pitesti provided information on water-quality problems and industrial emissions, and ICIM (the Research and Engineering Institute for the Environment) provided DEMDESS data on wastewater emissions, river flows, and stream water quality in the Arges basin for the 1992 calendar year.

Experts from PROED (the Studies and Design Institute for Public Works) provided information on existing treatment facilities and previous design studies, as well as data on water quality for the surface aquifer on the Arges portion of the Danube plain. In addition, information on municipal administration and finance was supplied by local officials in Pitesti, Cîmpulung, Curtea de Arges, Gaiesti, and Oltenita. Representatives of industries within the basin also cooperated with the study.

Local support for the project was provided by Inginerie Urbana S.A. under a WASH subcontract. Inginerie Urbana previously wrote the country report on wastewater emissions for the first WASH Danube study (op. cit., Volume III).

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Chapter 2

EXISTING CONDITIONS

2.1. General Features of the Basin

2.1.1 Location and Hydrological Conditions

The Arges River basin is located in the southeastern part of Romania. The Arges River and its major tributaries originate in the southern Carpathian Mountains, on the slopes of the Negoiu, Iezer, and Papusa mountains at elevations above 2,000 m. From the mountains, the Arges and its tributaries join and flow south-southeast, discharging into the Danube River near Oltenita, as shown in Figure 2. Major tributaries include the Doamnei, with its tributaries Tîrgului and Argesel; the Dîmbovita; and the Neajlov, with its tributary Dîmbovnic.

The Arges River basin is located between the basins of the Olt and Vedea rivers to the west and the Ialomita River to the east; all are tributaries of the Danube.

The basin area is 12,590 km^2 and the total length of the included water courses is about 3,665 km. The total length of the Arges River is 327 km.

On Dîmbovita and Tîrgului rivers (tributaries of the Arges), major reservoirs have been built in the mountains, namely the Vidraru, Pecineagu, and Rîusor. Along the main stem of the Arges River, 12 smaller lakes have also been constructed.

Hydrological data for the river and its tributaries are summarized in Table 9. The average stream flows and minimal dilution stream flows shown in the table are based on pre-1972 data, before many of the reservoirs in the basin were constructed to regulate flows. In many cases, the current regulated stream flows (under normal operating conditions) are higher than the naturally occurring dilution flows under drought conditions.

2.1.2 Climate

The climate of the basin is classified as "excessive continental." The year-round temperature is about 10°C. In January, the temperature across the basin ranges from below -10°C in the mountains to -8°C in Bucharest and -2° to -4°C in Pitesti and the immediate vicinity of the Danube River. The average temperature in July ranges from 8° to 10°C in the mountains to about 18° to 20°C in the Pitesti area, 22°C in Bucharest, and above 23°C at Oltenita.

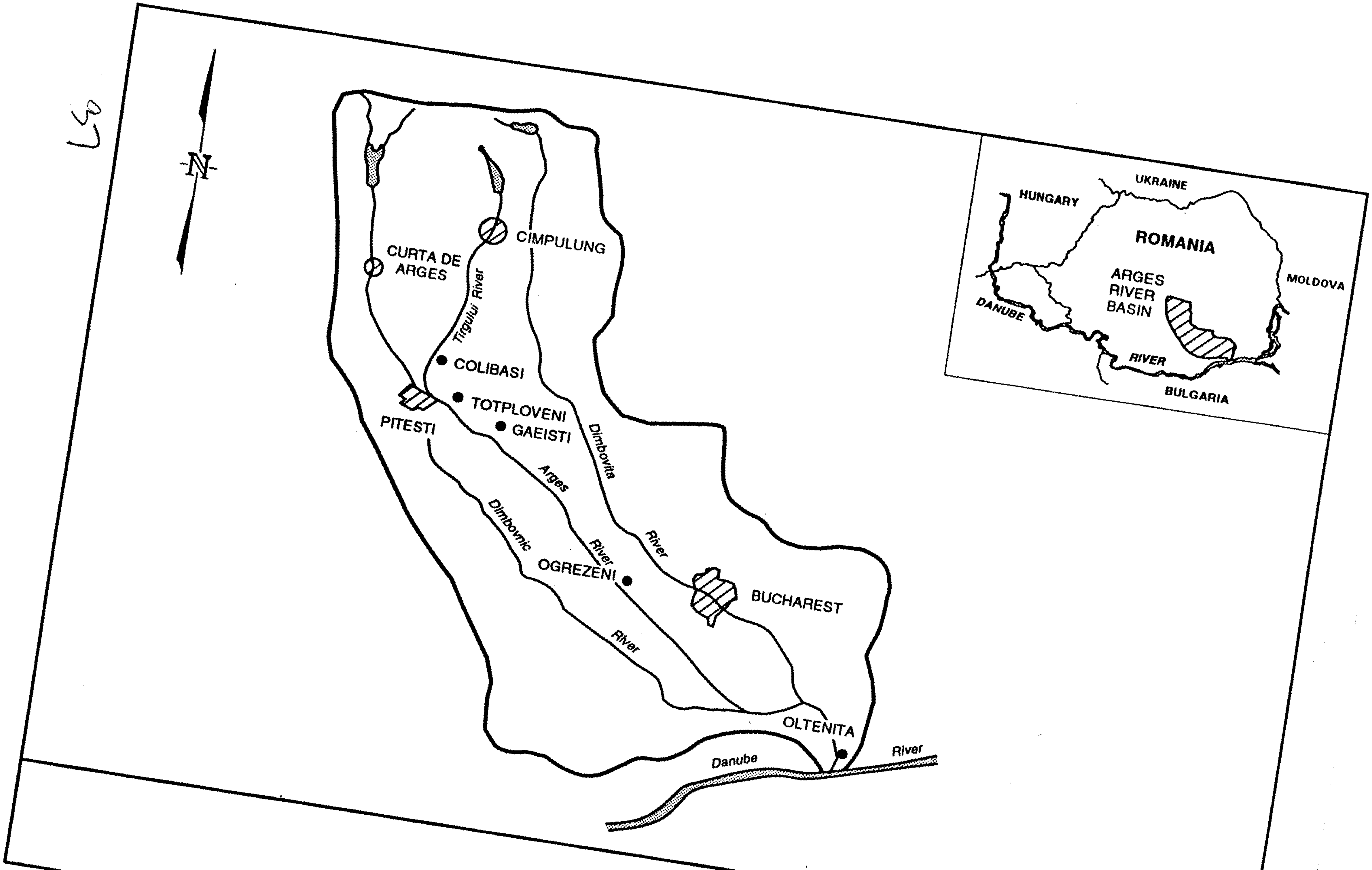

Figure 2
Map of the Arges Basin Study Area

Table 9

Hydrological Data for the Arges Basin

Tributary	On Tributary				Arges Upstream Confluence			
	Length (km)	Area (km^2)	Flow m^3/s Average	Flow m^3/s Minimum[a]	Location km[b]	Area km^2	Flow m^3/s Average	Flow m^3/s Minimum[b]
Buda	20	101	2.85	0.42	305	115	3.08	0.54
Valea lui Stan	11	21			297	278	6.88	1.30
Berindești	6	39			290	340	7.61	1.41
Bănești	13	38			279	441	8.40	1.44
V. Calului	5	24			267	587	9.45	1.62
Vilsan	76	347	4.00	0.47	247	738	10.12	1.73
Doamnei	98	1,820	20.33	3.50	228	1,265	14.81	3.00
Tirgului	67	1,079	9.48	2.58				
Rîncăciov	23	66			211	3,188	35.70	6.40
Gîrcinov	33	196	0.89	0.02	207	3,261	35.96	6.40
Budișteanca	27	118	0.48	0.01	197	3,474	37.10	6.40
Dîmbovnic	95	646	1.9	not reported				
Ogrezeni[c]					111	3,785	38.50	
Neajlov	150	3,660	6.60	0.66	56	4,070	38.94	6.47
Sabar	144	1,376	2.79	0.50	46	7,788	45.53	7.13
Dîmbovița	237	2,830	13.32	—	30	9,230	48.45	7.60
Luica	10	197	0.16	—	21	12,212	61.83	10.20
Mitreni	6	43			13	12,481	62.06	10.30
to Danube					0	12,590	65.15	10.40

Source: Water Cadastre Atlas of Romania, 1972

Legend

[a] Average flow = Average annual flow.

Minimum flow = Minimum monthly flow exceeded in 95 percent of years.

[b] River location = Distance on Arges River from the Danube, in kilometers.

[c] Ogrezeni = Location of Bucharest water supply intake.

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Annual precipitation ranges from more than 1,200 mm in the mountains to 500 mm near the Danube. The precipitation based on 90 years of observation is 665.2 mm in Pitesti, and 589.3 mm in Bucharest. The last 7 or 8 years were drier than average: in 1990, precipitation was 525.1 mm in Pitesti and 461.3 mm in Bucharest. The area's rainfall is distributed somewhat evenly throughout the year, with the highest rainfall occurring in June. May, June, and July account for 37 percent of the annual rainfall at Pitesti and Bucharest.

2.1.3 Topography

The Arges River and its major tributaries have their origin in the Carpathian Mountains at altitudes of 1,800 to 2,000 m, with the exception of the Neajlov River. In the mountains, the river slopes are pronounced and the flow velocity high. The main reservoirs (Vidraru, Rîusor, and Pecineagu) are located at elevations between 800 m and 1,000 m. However, after 20 to 30 km, the river courses enter the foothills at no more than 500 m in elevation, the slopes decline, and the velocity decreases to about 1.5 to 2 m/s. After another 30 to 50 km, the rivers flow onto the plain with reduced slope and diminished velocities of about 0.8 to 1.2 m/s or less, and follow meandering courses or wetlands.

The elevations in several hydrometric points are 570 m at Cîmpulung (Tîrgului River), 420 m at Curtea de Arges (Arges), 260 m at Pitesti (Arges), 75 m at Bucharest (Dîmbovita), and 18 m at Oltenita (Arges).

2.2 Socioeconomic Conditions and Land Use

2.2.1 Population

The major cities in the Arges basin are Bucharest, the capital of Romania, and Pitesti. The populations of these and smaller cities are listed in Table 10.

The basin area is located within the territories of six departments, or judets: Arges, Dîmbovita, Teleorman, Giurgiu, Calarasi, and Agricultural Sector Ilfov of Bucharest, as shown in Figure 2. The basin covers almost entirely the territories of the Arges, Dîmbovita, Sector Ilfov, and Giurgiu judets and only a small part of Teleorman and Calarasi. The urban and rural populations by judet are shown in Table 11.

Table 10

Population of Major Communities in the Arges Basin

City	Population (registered)
Bucharest	2,127,194
Pitesti	174,190
Cîmpulung	43,390
Curtea de Arges	32,550
Oltenita	32,513
Colibasi	24,605
Gaiesti	12,376
Videle	12,242
Titu	11,990
Total	2,471,050

Source: Romanian Statistic Yearbook, 1991

Table 11

Urban and Rural Populations by Judet

Judet	Population			As Percentage of Total	
	Total	Urban	Rural	Urban Areas	Rural Areas
Arges	680,056	295,285	384,771	43.4	56.6
Dîmbovita	566,509	177,370	389,139	31.3	68.7
Giurgiu	314,945	91,217	223,728	29.0	71.0
Calarasi	341,631	131,260	210,371	38.4	61.6
Bucharest	2,394,284	2,146,479	247,805	89.7	10.3
Teleorman	494,039	162,949	331,090	33.0	67.0
Totals	4,791,464	3,004,560	1,786,904	62.7	37.3

2.2.2 Land Use

The transportation network in the basin area is well developed. The area is traversed by railroad and roads from Bucharest to Pitesti, Cîmpulung, Curtea de Arges, Craiova, Constanta, and Giurgiu. The country's only highway, Bucharest-Pitesti, is located on the basin territory.

About 60 percent of the basin is used for agriculture. Table 12 shows the land use by hectare (ha) in each judet for various purposes. Forests are located in the mountainous areas, generally coniferous and beech. The total forested area in the basin is approximately 328,259 hectares, or about 26 percent of the basin.

Table 12

Land Use in Arges Basin

Judet	Total Area (ha)	Cultivated Area (ha)	Crop Cultivation		
			Cereals	Vegetables	Fodder Crops
Arges	680,100	171,085	111,816	9,940	36,940
Calarasi	507,400	420,631	245,456	14,811	60,998
Dîmbovita	403,600	182,204	122,171	10,089	38,650
Giurgiu	351,100	253,466	164,358	10,186	44,336
Teleorman	516,000	466,404	288,062	19,839	69,979
Bucharest-SAI	182,000	114,881	66,379	9,943	27,366
Totals	2,640,200	1,608,671	998,242	74,808	278,269

2.2.3 Economic Development

The number of workers by economic sector for the basin area is summarized in Table 13. The average net wage in 1991 was 7,489 lei per month or $US 46.80 per month.* After

* Figures given for average net wage, unemployment rate, average lodging area, and average family size are the most current available. It should be noted that differences in exchange rates, buying power, and local taxes since 1991 likely have altered the basin's salary data.

Table 13

Employment by Economic Sector, 1990

Judet	Total	Industry	Construction	Agriculture	Forestry	Services and Others
Arges	254,700	136,200	17,900	13,600	1,500	85,500
Calarasi	105,800	33,200	10,900	27,400	500	33,800
Dîmbovita	179,800	106,000	11,000	12,900	900	49,000
Giurgiu	77,700	25,400	6,300	15,800	600	29,600
Teleorman	125,200	54,600	5,900	20,300	700	43,700
Bucharest	1,131,000	481,200	124,600	17,100	500	507,600
Totals	1,874,200	836,600	176,600	107,100	4,700	749,200

accounting for local prices and taxes the equivalent salary was about $US 165 per month. The region's unemployment rate in 1991 was about 8 percent, the average lodging area was 11 m^2 per capita, and the average family size was 3.2 persons.

Despite the attractions offered by the natural landscape, especially in the mountain area, tourism is not well developed in the basin.

2.3 Water Resources Development and Water Uses

2.3.1 Hydrotechnological Developments

Dams have been constructed in the Arges River basin, mainly for hydropower, municipal and industrial water supply, and flood control. Potential water needs for irrigation were considered in the planning and construction of the dams, but large-scale, formal irrigation systems are limited to the area surrounding Oltenita, where water is taken from the Danube rather than the Arges.

As shown in Table 14, the major dams in the basin are Vidraru on the Arges River, Rîusor on the Tîrgului River, and Pecineagu on the Dîmbovita River; all are in the mountains and provide water supplies: Vidraru for Pitesti and Bucharest, Rîusor for Cîmpulung, and Pecineagu for Bucharest. Bascov and Budeasa lakes are used as the intakes for Pitesti water supply, and Ogrezeni Lake as the Bucharest water supply intake. Large regulated releases are needed in the cold winter period to prevent freezing of the shallow intake at Ogrezeni.

The Colentina River, a tributary of the Dîmbovita, has a very shallow slope and in the past has caused flooding and drainage problems. The Municipality of Bucharest has transformed the river course by installing a series of lakes, which are used mainly for recreation. One of the lakes, Cernica, is also used as a source of industrial water. The lakes in the mountains and near Pitesti are also recreational areas. On the upper Arges and Dîmbovita are several small trout farms. Only Bascov Lake at Pitesti is used directly for cooling water.

The main reservoirs are operated by RENEL, the National Autonomous Power Authority, based on schedules agreed upon with Apele Romane (the Romanian Waters Authority) and the municipalities concerned.

2.3.2 Municipal Water Supply

The Institute of Hygiene and Public Health provided the WASH team with information on six water supply systems: Cîmpulung, Curtea de Arges, Gaiesti, Pitesti, Titu, and Videle. An analysis of this information is contained in Chapter 4.

A summary of information on public water supply systems in the six judets lying in whole or in part within the Arges basin is shown in Table 15, taken from the Romanian statistical yearbook for 1991.

Table 14

Waterworks for Hydropower, Water Supply, and Irrigation

(A) Reservoirs

Reservoir	Volume (million m^3)		General Purpose	Characteristics
	Total	Useful		
Vidraru on Arges	505.0	420.0	Electric power Water supply Irrigation	400 GWh[a]/year 15.80 m^3/s 55,000 ha
Zigoneni on Arges	13.3	10.9	Electric power	26.0 GWh/year
Vilcele on Arges	49.8	41.3	Electric power Irrigation Flow regulation Flood attenuation	28.3 GWh/year 6,300 ha
Budeasa on Arges	55.0	24.0	Electric power Flood attenuation Water supply Water supply	22.76 GWh/year Pitesti City + 1.1 m^3
Bascov on Arges	Filled with sediments	1.5	Electric power	~15.0 GWh/year
Pitesti on Arges	Filled with sediments	—	Electric power Water supply	19.0 GWh/year Petrochemical combine
Riusor on Tirgului	50.0	15.6	Water supply Irrigation Electric power	2.54 m^3/s 8,500 ha 45.5 + 12.7 GWh/year
Golesti on Arges	78.50	52.50	Water supply Reserve water supply Irrigation Electric power	1.8 m^3/s 6.0 m^3/s for Petrochemical combine 10,000 ha 33.0 GWh/year
Mihailesti on Arges	104.31	42.0	Irrigation (in future navigation)	15,000 ha
Pecineagu on Dîmbovita	69.0	62.0	Water supply Irrigation Electric power	3.0 m^3/s 10,700 ha 120 GWh/year

(continued)

Table 14 (continued)

Reservoir	Volume (million m^3)		General Purpose	Characteristics
	Total	Useful		
Vacaresti on Dîmbovita	53.7	11.0	Water supply Irrigation Electric power	0.37 m^3/s 2,300 ha 11.70 GWh/year
Udresti, Bungetu I & I, Bratesti, Adunati, Ilfoveni on Ilfov	22.0	15.5	Water supply Irrigation	0.66 m^3/s 28,705 ha
Gradinari, Facau on Ilfovat	20.0	13.5	Irrigation	4,100 ha
15 Reservoirs on Colentina, from which:				
Buftea	14.55	9.1	Irrigation	2,816 ha
Pantelimon II and Cernica	22.71	10.6	Irrigation Industrial water supply	981 ha 3.0 m^3/s

(continued)

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Table 14 (continued)

(B) Existing Flow Diversions (Channels and Pipes)

From	To	Purpose, Average Flow
Topolog River	Vidraru Reservoir	Power, 2.4 m^3/s
Doamnei River Vilsanu River	Vilsanu River and Vidraru Reservoir	Power, 8.5 m^3/s
Arges River	Ilfovat River	Irrigation, 0.5 m^3/s
Arges River	Sabar (Crivina)	Irrigation, 1.5 m^3/s
Arges (Crivina)	Dîmbovita (Bucharest)	Water supply, 8.5 m^3/s
Arges (Crivina)	Dîmbovita (Arcuda)	Water supply, 0.2 m^3/s
Crivina-Rosu channel (Dragomiresti)	Colentina (Chitila)	Water supply, 8.5 m^3/s
Lunguletu (Arges)	(Dîmbovita)	Water supply, 2.8 m^3/s
Ialomita	Ilfov	Water supply, 0.65 m^3/s
Ialmomita (Bilciuresti)	Colentina	Water supply, 1.2 m^3/s
Dîmbovita	Ilfov (Vacaresti reservoir)	Water supply, 0.2 m^3/s
Ilfov	Dimbovita (Mircea Voda)	Water supply, 4.0 m^3/s

(C) Diversions for Flood Control Only

From	To	Average Flow
Dîmbovita	Arges (Brezoaiele)	515 m^3/s
Ilfov, Dîmbovita	Ciorogirla (Arcuda)	10 m^3/s
Ilfov	Colentina (Bolovani)	50 m^3/s
Sabar, Potopu	Arges (Gaiesti)	900 m^3/s

[a] GWh = gigawatt hours.

Table 15

Potable Water Supply Systems in the Arges Basin, 1990

Judet	Localities with Water Supply Systems	Length of Water Network, km	Total Water Supplied in Million m^3	Water for Domestic Use in Million m^3
Arges	91	1,019	95.3	47.8
Bucharest	32	2,133	439.3	199.1
Calarasi	24	555	22.4	10.1
Dîmbovita	78	455	26.8	13.3
Giurgiu	16	155	19.4	7.9
Teleorman	15	405	36.8	13.6
Totals	256	4,722	640.0	291.8

The portion of the population served by the public water supply systems is generally high, exceeding 95 percent in Bucharest and averaging 89 percent in the five systems surveyed outside Bucharest. Service is predominantly via piped supply to the customer's premises (85 percent of customers), but in peri-urban areas the population is also served by a combination of yard taps (15 percent) and neighborhood standpipes (less than 0.1 percent). Water treatment of surface supplies and chlorination of both surface and groundwater supplies are provided, although several previous reports and WASH visits to treatment plants indicate problems and deficiencies in potable water treatment similar to those encountered in wastewater treatment plants.

2.4 Public Health

The adverse effects on human health caused by wastewater in the Arges basin cannot be demonstrated from the available statistical data. The incidence of waterborne infections, parasitical diseases, and death rates are aggregated by judet, and do not allow a localized analysis or ranking of human health effects associated with various environmental threats. However, a 1992 World Bank Joint Environment Strategy Mission in Romania noted that cancer mortality for 1979—83 in Bucharest was about two times higher than that in the district of Gorj (which had the lowest mortality).

Data provided in the Romanian statistical yearbook for 1991 for the five judets in the Arges River basin are shown in Table 16. The infant mortality rate in Romania is low by world standards, based on a 1992 UNICEF publication (*The State of the World's Children, 1992*). According to the report, in 1990, Romania had a rate of 27 deaths per 1,000 births, ranking 87 out of 129 countries.

Table 16

Public Health Statistics

Judet	Number of Inhabitants per Physician	Death Rate per 1,000	Infant Mortality <1 year, per 1,000		
			Total	Urban Area	Rural Area
Arges	515	10.2	23.8	18.8	27.4
Dîmbovita	575	11.5	28.1	23.8	30.0
Bucharest	351	10.4	21.5	19.9	33.4
Giurgiu	575	14.2	31.9	30.6	32.5
Calarasi	655	12.1	38.3	38.7	38.0
National Average	514	10.6	26.9	24.1	29.7

Despite the quite uniform level of medical care available, the rates for total deaths and infant deaths are lowest in the upstream part of the Arges basin and increase downstream. Higher infant mortality rates in rural areas might be attributed in part to the high levels of nitrates found in the shallow wells used for rural water supply.

The Ministry of Health indicates that about half of the basin's infant mortality is due to respiratory diseases, with very few attributed to gastrointestinal diseases. The incidence of dysentery and typhoid fever in the general population also appears to be low compared with that of other countries. On this basis, the drinking water supplies appear to be safe from bacteriological contamination, but the high incidence of hepatitis may indicate either viral contamination of water supplies or unsanitary conditions, including exposure to wastewater.

2.5 River Water Quality

2.5.1 Standards for River Water Quality and Discharges to Rivers

Selected Romanian river water-quality standards (from Romanian Standard 4706) are shown in Table 17. Romania's waterways are classified into three categories, as follows, based on permitted water uses:

Category I — Surface water used for urban water supply, food industries, and other industries requesting drinking water quality; swimming pools.

Category II — Surface water used for aquaculture and water-contact recreation.

Category III — Surface water used for irrigation, industrial supply, and other uses not included in the higher-quality categories.

Water that fails to meet the standards for Category III is degraded and is considered a fourth category.

Figure 3 illustrates the basin's main bodies of water broken down by stream-quality classification; Table 18 indicates the percentage of rivers in the basin that are classified in each of the four categories.

Table 17

Selected River Water Quality Standards (in mg/L)

Parameter	River Category I	II	III	Testing Frequency
Dissolved oxygen	6	5	4	Daily
Total dissolved solids	750	1,000	1,200	Daily
Chloride	250	300	300	Daily
Chemical oxygen demand (Mn)	10	15	25	Daily
Ammonia	0.1	0.3	0.5	Daily
Nitrates	10	30	NA	Daily
Nitrites	1.0	3.0	NA	Daily
Phenols	0.001	0.02	0.05	Daily
Cyanide	0.01	0.01	0.01	Daily
Cadmium	0.003	0.003	0.003	Weekly
Hexavalent chromium	0.05	0.05	0.05	Weekly
Copper	0.05	0.05	0.05	Weekly
Iron	0.3	1.0	1.0	Weekly
Manganese	0.1	0.3	0.8	Weekly
Nickel	0.1	0.1	0.1	Weekly
Lead	0.05	0.05	0.05	Weekly
Zinc	0.03	0.03	0.03	Weekly

Table 18

River Lengths by Stream-Quality Category

Category	Approximate Percentage of River Lengths in Category	
	National Value	**Arges Basin**
Category I	39	35
Category II	30	29
Category III	12	14
Degraded	19	22

Standards for point-source discharges (and thus effluent) from Romania's various types of treatment plants have been established by executive decree (Decree 414/1979). Under the decree, limiting values for five-day biochemical oxygen demand (BOD_5 and suspended solids depend on the dilution flow available in a stream, as shown in Table 19. The allowable values for pH are 6.5 to 8.5 for all dilutions, while the range of values for most heavy metals varies from 0.01 to 0.5 mg/L and is constant for all dilution levels.

Allowable limits for constituents in specific wastewater discharges ideally should be established by a wasteload allocation procedure, designed to achieve or protect target water-quality levels associated with the existing or desired water uses. While the decree standards now in use provide a logical set of target levels, procedures for establishing and issuing discharge permits for individual dischargers have not been formalized.

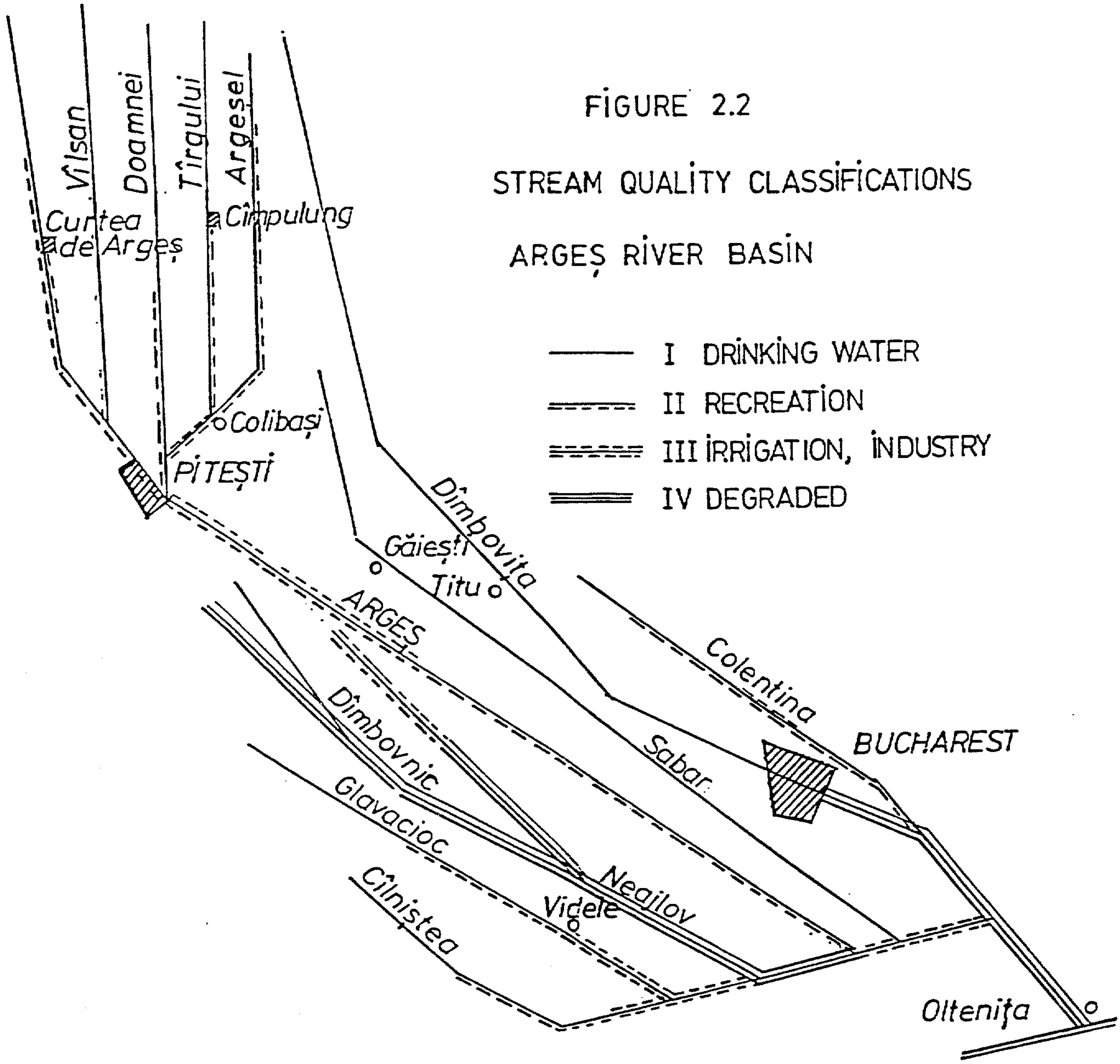

Figure 3

Stream-Quality Classifications, Arges River Basin

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Table 19

Treated Effluent Criteria

Constituent	Dilution Rate 1:1	1:50	1:100
	Concentration (mg/L)		
BOD_5	15	60	100
Suspended solids	25	100	200
Hydrogen sulfide	0.01	1.0	2.0
Chromium	0.01	1.0	2.0
Iron	2.0	5.0	8.0
Mercury	0.01	0.01	0.01
Cadmium	0.10	0.10	0.10
Lead	0.20	0.20	0.20
Zinc	0.10	0.50	1.00
Detergents	0.5	15.0	30.0
Phenol	0.2	0.3	0.6

2.5.2 Analysis of 1992 Stream-Water-Quality Data

During 1992, the environmental inspectorate in Pitesti collected water-quality samples at 32 monitoring stations in the Arges basin, quantifying 7,630 values for 32 water-quality parameters. The locations of 42 monitoring stations are shown in Figure 4; 10 of the stations represent confluences of rivers. The locations of wastewater emissions dischargers in relation to the locations of water-quality monitoring stations are shown schematically in Figure 5.

Analysis of the DEMDESS database for this study generally confirmed the stream classifications shown in Figure 3. This analysis was also confirmed by WASH-team field visits to portions of the most polluted rivers. Consequently, the team ranks pollution in the various river reaches as follows:

- The Dîmbovita River below the Glina wastewater treatment plan (WWTP) and the Arges River downstream to the Danube are the most heavily polluted stretches, as might be expected from the discharge of raw sewage from metropolitan Bucharest.

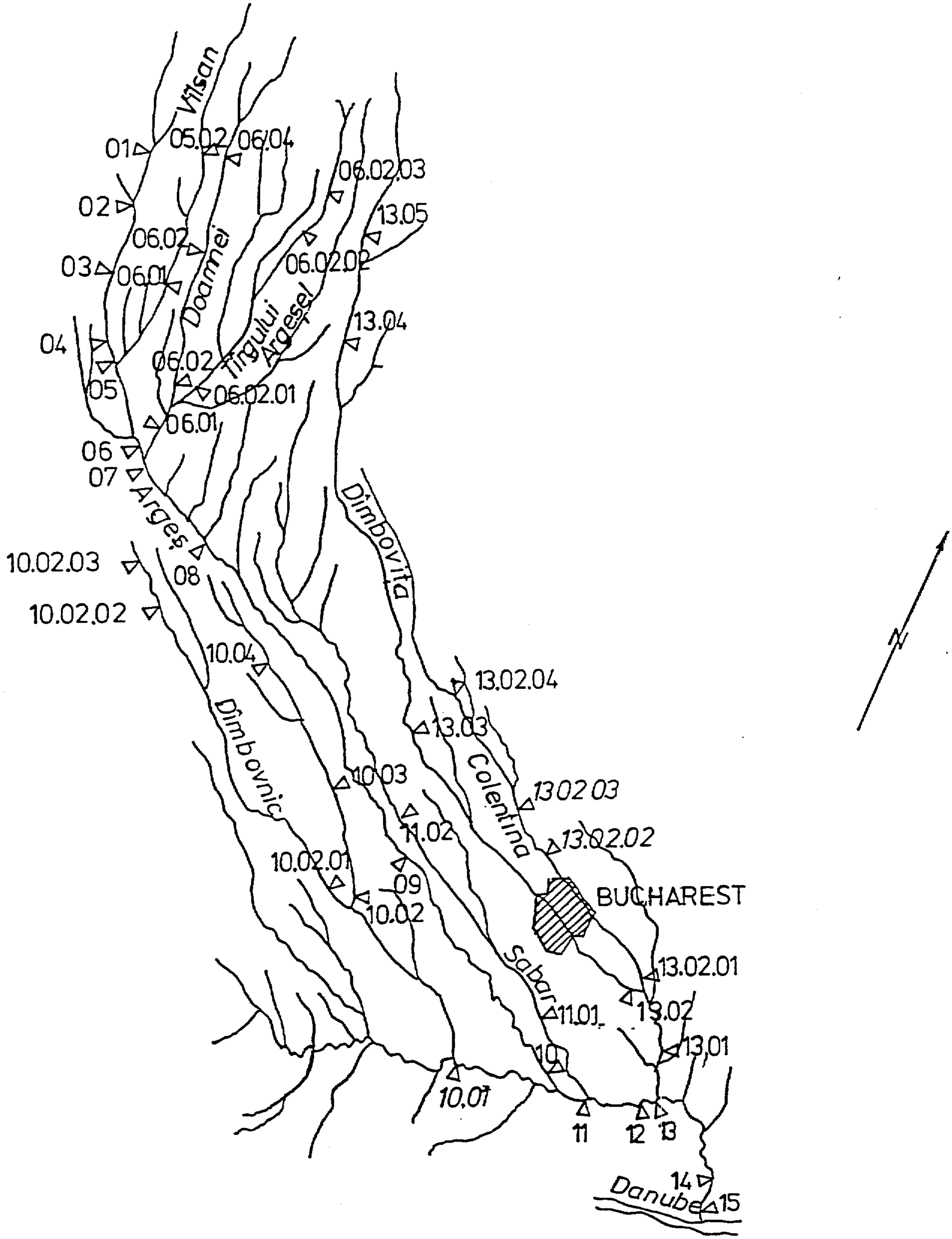

Figure 4

Location of Water-Quality Monitoring Stations in the Arges River Basin

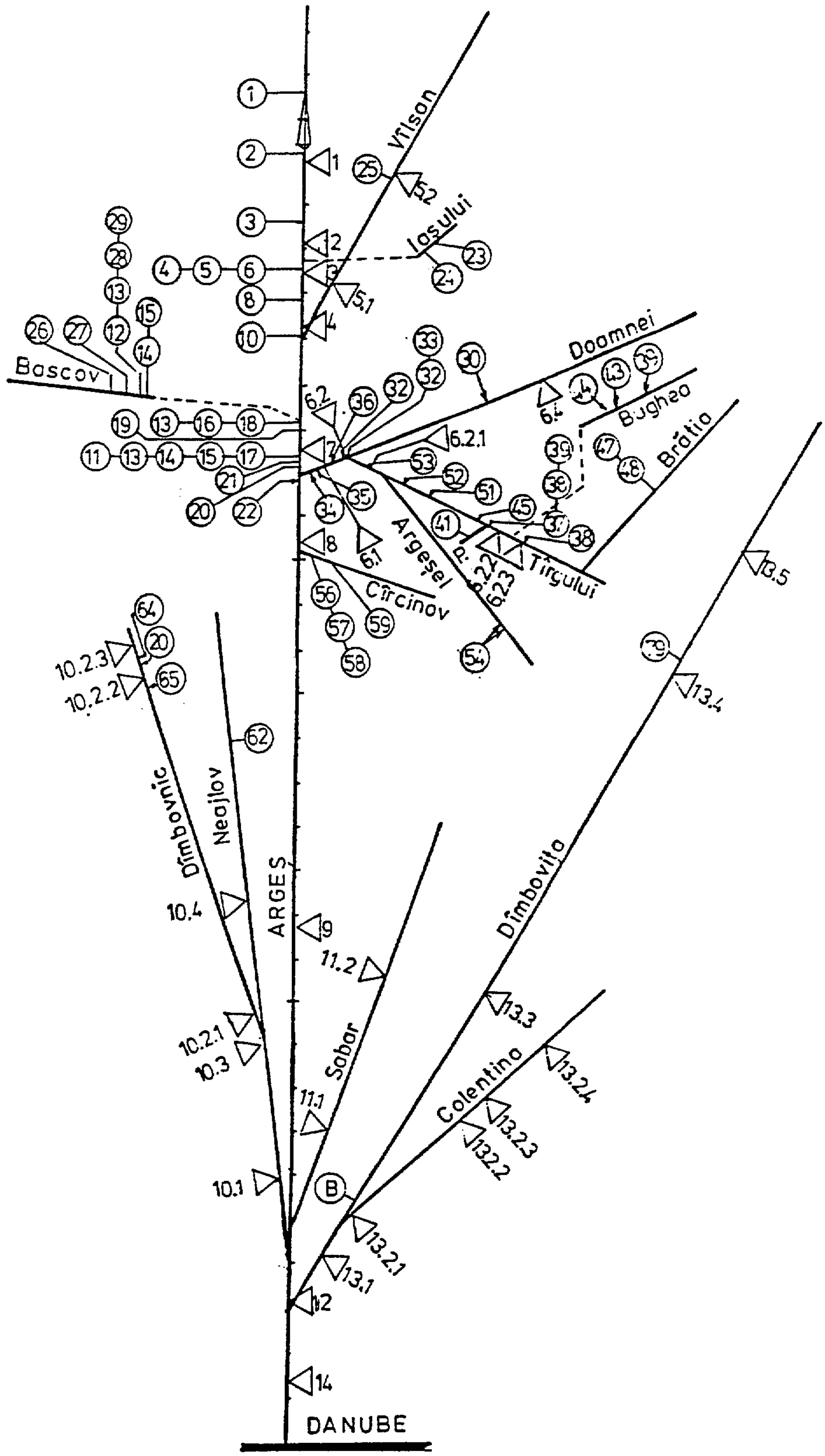

Figure 5

Schematic, Dischargers and Water-Quality Monitoring Stations

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- The Dîmbovnic below the Arpechim petrochemical complex and the Neajlov and Arges rivers downstream are heavily polluted by industrial wastewater effluents from Arpechim.

- The Arges River, in the critical stretch from above Pitesti to the Ogrezeni water supply intake for Bucharest, contains noticeably high levels of organic pollution indicative of eutrophication; however, the ability to prove that such pollution is caused by eutrophication depends on documented instances of algae blooms affecting the odor, taste, and treatability of water for potable supplies in Pitesti and Bucharest.

Detailed information on the extent of water pollution in the Arges basin is provided in Appendix A. This includes DEMDESS plots of the seasonal variations in nutrient levels (nitrates, ammonia, and phosphates) within the upper basin; profiles along rivers of the 1992 average, maximum, and minimum values for many contaminants; and a listing of water-quality samples that exceed the limits allowable for Category I or II waters.

Table 20 summarizes the above water-quality monitoring data in terms of the parameters tested for, allowable limits, number of sites, number of samples analyzed for each parameter, and percentage of samples that failed to meet the limits stipulated for Category I or II. The maximum concentrations found in each river that exceed the same Category I/II standards are summarized in Table 21. (Note: Analyses for synthetic organic chemicals and metals were too inadequate to measure the extent of contamination.)

The results indicate the following with respect to the water-quality parameters cited:

- Ammonia levels exceed the Category I standard (0.1 mg/L) in essentially all samples, which is attributable in most cases to wastewater discharges. Also, the noticeable but not severe increase in ammonia levels between Pitesti and Ogrezeni may be attributable to agricultural runoff from the Danube plain.

- Organic pollution (BOD_5, COD-Mn) is seasonally high at many of the stations, but dissolved oxygen (DO) levels in streams are generally good (with the obvious exception of the Dîmbovita and lower Arges).

- High concentrations of metals do not appear to be a pervasive problem, but available data (in terms of number of sites and number of samples) are too few to verify this premise. Some threat to health from toxins is assumed but cannot be quantified with available data.

- Nitrate levels are sufficiently high throughout the basin to support eutrophication and algae growth. Evidence is limited that a small portion of the nitrates at Ogrezeni are caused by non-point-source agricultural runoff downstream from Pitesti.

- Phosphate and other forms of phosphorus appear to be the limiting nutrient for eutrophication, rather than carbon or nitrogen. Phosphates are measured at many of the monitoring stations, but the stream-quality standards set no limit for them to protect various types of lakes. However, Romanian standards do include limits for total phosphorus: less than 0.03 mg/L for oligotrophic lakes (very clean water devoid of algae); less than 0.1 mg/L for mesotrophic lakes (intermediate concentrations of algae); and more than 0.15 mg/L for eutrophic lakes. Each 1 mg/L of phosphates (measured as PO_4^{-3}) equates chemically to about .33 mg/L of phosphorus; therefore, phosphates contain only about one-third of the total phosphorus found in a river. Thus, concentrations of phosphates may equal the total phosphorus concentration. Table 22 considers varous potential phosphate limits Romanian standards could impose, and shows the percentage of monitoring sites and water samples that would exceed allowable limits under each scenario.

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Table 20

Summary of Stream-Water-Quality Monitoring Data

Code	Parameter	Limit* Cat. I/II	Units	TOTAL TESTS No. of Sites	TOTAL TESTS No. of Samples	LIMITS EXCEEDED No. of Sites	LIMITS EXCEEDED No. of Samples	PERCENTAGE EXCEEDED WQ Sites %	PERCENTAGE EXCEEDED Samples %
1	BOD-5	2.000	mg/l	29	334	29	307	100.0	91.9
2	COD-mn	10.000	mg/l	32	371	18	104	56.3	28.0
5	Ammonia NH3	.100	mg/l	31	303	31	248	100.0	81.8
6	Nitrates NO3	10.000	mg/l	32	345	8	14	25.0	4.1
7	Chloride CL	250.000	mg/l	32	371	5	26	15.6	7.0
8	Sulphate SO4	200.000	mg/l	32	371	3	3	9.4	.8
11	Phenols	.001	mg/l	13	86	12	80	92.3	93.0
12	Iron Fe	.300	mg/l	28	288	17	54	60.7	18.8
13	Manganese Mn	.100	mg/l	20	116	12	69	60.0	59.5
17	Lead Pb	.050	mg/l	10	23	2	2	20.0	8.7
18	Copper Cu	.050	mg/l	13	61	1	1	7.7	1.6
19	Zinc Zn	.030	mg/l	10	53	0	0	0.0	0.0
20	Detergents-anionic	.500	mg/l	30	294	2	2	6.7	.7
23	DO mg/l	6.000	mg/l	32	366	13	68	40.6	18.6
24	pH	6.500	-	32	371	0	0	0.0	0.0
28	Nitrites	1.000	mg/l	32	362	7	12	21.9	3.3
33	Cadmium	.003	mg/l	8	63	1	1	12.5	1.6
36	Nickel	.100	mg/l	3	15	3	15	100.0	100.0
38	Cyanide, total (CN)	.010	mg/l	9	63	6	35	66.7	55.6
42	Mercury (Hg)	.001	mg/l	1	1	0	0	0.0	0.0
46	Calcium, Ca	150.000	mg/l	32	371	1	1	3.1	.3
47	Magnesium, Mg	50.000	mg/l	32	371	3	3	9.4	.8
62	Sodium, Na	100.000	mg/l	32	351	11	62	34.4	17.7
109	Chromium - Cr-6	.050	mg/l	8	58	1	1	12.5	1.7

*Limits for Category I, except for parameters where limits are given only for Category II waters

Table 21

Largest Stream-Quality Concentrations above Category I/II Limits

Code	Parameter	Limits[a]	Arges	Neajlov	Dîmboviţa	Dîmbovnic	Colentina	Sabar
2	COD-Mn	10.0	22.640 km 31	17.060 km 54	24.160 km 15	32.200 km 85	16.700 km 2	36.600 km 24
5	Ammonia	0.1	11.390 km 31	5.810 km 86	15.210 km 15	30.600 km 85	3.470 km 44	17.200 km 24
6	Nitrates	10.0		17.160 km 54		12.900 km 4	13.700 km 2	16.490 km 24
7	Chloride	250.0		8,666.7 km 54		282.430 km 4		
11	Phenols	0.001	0.369 km 31	0.030 km 20	0.478 km 15	0.890 km 85	0.027 km 36	0.087 km 24
12	Iron	0.3		0.745 km 20		0.983 km 85		
13	Manganese	0.1	4.860 km 118		0.468 km 15	0.474 km 4		
17	Lead	0.05	0.272 km 13		0.056 km 15			
28	Nitrites	1.0	1.490 km 13	3.490 km 20		3.290 km 4	1.13 km 62	1.725 km 24
36	Nickel	0.01	0.372 km 31		0.299 km 15			
38	Cyanide	0.01	0.044 km 31	0.067 km 20	0.047 km 15	0.143 km 4		
109	Chromium	0.05			0.091 km 15			

[a] Limits represent those for Category I (or II if not stipulated for I) drinking water sources, according to Standard 4706/88.

Table 22

Possible Phosphate Limits and Frequency Exceeded

Possible Limit on PO_4^{-3} (mg/L)	Number of Sites	Number of Samples	Sites (Percent)	Samples (Percent)
0.03	30	302	100	100
0.10	22	98	73	32
0.15	19	77	63	25
0.20	15	54	50	18
0.40	11	26	37	9

Apele Romane in Pitesti has conducted a study on the eutrophication of the Budeasa and Bascov lakes, which are also the intake points for Pitesti's water supply. There was insufficient time to obtain a copy of the report for use in this study, however. The WASH team did learn that eutrophication has caused severe odor and taste problems in Pitesti's drinking water supply, particularly since the appearance of blue-green algae starting in 1990. Additionally, the chlorination of the water poses a potential health risk from THM production (trihalomethane, a carcinogen).

The origin and control of phosphates in a river basin is difficult to ascertain, and particularly so in the Arges basin, as stream flows in the Arges have been very low in recent years. The DEMDESS stream flow data for 1992 are close to the 95 percent low stream flows that would occur in the natural (unregulated) regime. Beginning in 1990, there arose evidence of some eutrophication in the large Vidraru Reservoir, in the virtual absence of man-made pollution; this is attributed to warmer temperatures and shallower water depths in the reservoir during the current 8 to 10 year drought period.

A further complicating factor is the large number of small shallow lakes along the Arges, which are filling with sediment. Compared with natural conditions, the lakes reduce flow velocity and allow settling of sediments, which improves the clarity of the water; penetration of sunlight allows larger algal production. Phosphates and other forms of phosphorus accumulate in the lake sediments and can be re-suspended during seasonal periods of turnover (if the lake is thermally destratified in the spring and fall) or during flood flows. In the United States, the introduction of low-phosphate detergents has been beneficial in several portions of the country, and the same could prove true in Romania. Groundwater in the Danube plain below Pitesti contains high concentrations of phosphates from animal feedlots and perhaps overapplication of fertilizers, but it appears that very little of the groundwater seeps into the rivers to affect surfacewater quality.

Despite these complicating factors, control of point-source emissions of phosphates (and other forms of phosphorus) by improvements at industrial and municipal treatment plants can provide a substantial improvement in the levels of phosphorus. (This topic is discussed further in Chapter 3 of this report.)

2.6 Groundwater Quality

2.6.1 Context

Larger communities in the Arges River basin use surface water as their source of treated drinking water. The basin also runs several large municipal and industrial well fields, including the Bucharest well fields (about 8 percent of the city's supply) and the wells for the cities of Colibasi (population 24,300), Găiesti (17,400), and Topoloveni (8,400). Without exception, the public-supply wells in the foothills and Danube plain penetrate the deeper-confined aquifers because water quality of the phreatic aquifer within the plain is unsatisfactory for potable supply.

In contrast, the rural population frequently uses shallow hand-dug wells in the phreatic aquifer for private water supplies. The water quality of the phreatic aquifer is a major topic of concern, because a large proportion of the total basin population outside Bucharest is rural, as illustrated by the judet population statistics shown in Table 11.

Groundwater infiltration to rivers within the Danube plain is apparently negligible, and thus the concentrations of pollutants in groundwater do not affect the feasibility of projects to reduce eutrophication and surface water pollution.

2.6.2 Lithology and Hydrogeology

The Danube plain represents a major part of the basin area and contains the vast majority of the basin's private shallow wells. As mentioned previously, these wells are dug in the plain's phreatic aquifer.

The next three aquifers are a succession of sand-gravel, gravel-sand, and coarse sand with rare gravel. The depth of these aquifers is generally at 15 to 300 m and occasionally 500 m, and their porosity is high. The larger municipal and industrial well fields in the basin, including the Bucharest underground sources, draw water from these aquifers. These aquifers are fed from the Carpathian Mountains and drain toward the Danube.

The deepest aquifer is composed of gravel lying under a layer of marl, which in turn lies under several sandy layers intercalated with clayey loams in the first 300 to 500 m below ground. The deepest aquifer is fed from the Balkan Mountains in Bulgaria and has a general slope from the Danube running east-northeast to the Black Sea. Moving from the Danube, the water temperature and the depth to the deep aquifer increase: 15° to 18°C and 200 m deep at Giurgiu, and 45° to 50°C and 600 m deep at Bucharest. This aquifer is being investigated as a possible standby source for Bucharest.

2.6.3 Assessment of Groundwater Quality

Water-quality data for rural private shallow wells in the Arges basin are very limited, because the wells are not regulated or inspected, and because they are numerous and broadly distributed within the basin. However, certain wells (owned mainly by enterprises) are tested in a systematic program of water-quality sampling and testing. This program covers 99 wells lying in the heavily populated foothills and Danube plain, between Pitesti and the Danube.

A table showing the average annual values for monthly tests on groundwater quality in the phreatic aquifer in 1991 is available at the WASH Operations Center. It indicates only those parameters whose levels exceed the limiting concentrations for drinking water quality under Romanian Standard No. 1342-91.

The data show frequent large concentrations of nitrates, phosphates, and organic matter (expressed as COD by potassium permanganate consumption). Wells having large concentrations of chlorides are located mainly in the oil fields (where excessive amounts of water are injected for oil recovery) and in the vicinity of the Arpechim petrochemical complex.

Several causes of the high levels of nutrients in the groundwater are easily identifiable from the types of land use in the vicinity of each well. These result in wastes from pig farms, seepage from latrines and septic tanks in the unsewered portions of Bucharest and other communities, and surface infiltration from agricultural lands where inorganic chemical fertilizers were applied frequently and heavily in the past. Recovery in quality of the phreatic aquifer, if all these causes were eliminated, would take centuries due to the low rainfalls and low infiltration rates available to flush the aquifer.

It is apparent that the most serious pervasive threat to public health in the Arges basin that can be attributed to water quality is associated with the nutrient levels in the phreatic aquifer. The solution to the problem also seems apparent, in that the deeper aquifers could provide an abundant supply of good-quality drinking water, as a vast improvement over the use of shallow hand-dug wells.

It should be noted that the levels of nutrients in the phreatic aquifer exceed the safe levels for infants by a factor of 4 to 10, and it should be possible to prove a high incidence of methemoglobinemia (blue baby syndrome) in rural areas. The evidence of such an investigation in turn could justify a program to develop rural water supplies.

Chapter 3

EXISTING EMISSIONS AND WASTEWATER TREATMENT

3.1 Summary of Available Data

Data on emissions in the Arges basin were supplied by ICIM and the local inspectorate in Pitesti and have been entered into the DEMDESS database. These data consist of more than 3,000 samples and contain wastewater flow and quality information for 72 major dischargers in the basin, including municipal and industrial emissions. Table 23 summarizes the parameters measured in the emissions in the study area. Notably absent from the data are measurements of organic nitrogen, pesticides, mercury, and lead. Additionally, some discrepancies occurred between data sources (ICIM, the inspectorate, and WWTP operations records).

Table 23

Summary of Emissions Sampling in the Arges Basin, 1992

				Parameter Detected	
PARMCODE	Emission Parameter	Total Sites	Total Samples	Number of Sites	Number of Samples
1	BOD_5	58	151	58	151
2	COD-Mn	57	151	57	151
4	TSS	58	151	58	151
6	Nitrates	57	149	57	147
7	Chloride	56	150	56	150
9	Hydrogen sulfide	4	5	0	0
10	Oil	26	41	5	6
11	Phenols	26	59	21	32
12	Iron	42	101	40	91
14	Phosphates	56	147	56	145
15	Chromium	18	60	2	2
18	Copper	13	49	12	38
19	Zinc	11	30	9	16

(continued)

Table 23 (continued)

PARMCODE	Emission Parameter	Total Sites	Total Samples	Parameter Detected: Number of Sites	Number of Samples
20	Detergents-anionic	43	92	41	90
24	pH	57	151	57	150
25	Total solids	57	150	57	150
28	Nitrites	57	151	57	143
33	Cadmium	12	44	11	38
36	Nickel	12	43	0	0
38	Cyanide, total	26	65	4	8
46	Calcium	1	2	1	2
47	Magnesium	2	3	2	3
62	Sodium	3	6	3	6
112	Ammonium	57	150	56	148
Totals		809	2,101	720	1,819

3.2 Municipal Wastewater Systems

3.2.1 Municipal Sewerage Facilities

The sewer systems in Bucharest, Pitesti, and other municipalities are predominately combined sewer systems, carrying both storm water and wastewater. The portion of population served by the sewer systems is about 90 to 95 percent in the larger municipalities, while in smaller towns such as Gaiesti only the population in newer apartment blocks is connected to sewers. For the unserved population, dry pit latrines are the most common on-site disposal systems. Domestic housing receiving public water supply is sometimes connected to a nearby storm drain, but this situation is uncommon and was observed by the WASH team in only one instance, in Rucar.

Limited data on public sewer systems, from the Romanian statistical yearbook for 1991, are shown in Table 24.

Table 24

Public Sewer Networks by Department, 1990

Judet	Total Number of Sewer Systems	Municipalities with Sewer Systems	Total Length of Sewers, km
Arges	16	6	404
Bucharest	23	2	1,748
Calarasi	5	4	142
Dîmbovita	10	6	142
Giurgiu	4	3	88
Teleorman	9	5	195
Totals	67	26	2,719

3.2.2 Municipal Wastewater Treatment Facilities

Information is available from WASH team visits and the previous USAID Danube study on the facilities at the four major wastewater treatment plants in the basin, serving Bucharest, Pitesti, Cîmpulung, and Curtea de Arges. These account for about 98 percent of municipal wastewater generated in the Arges basin. Major findings of the site visits and interviews are summarized below.

General deficiencies

All of the operating wastewater treatment plants assessed in this study had several problems in common. These include lack of modern reliable laboratory equipment; lack of continuous flow measurement, data logging, and recording equipment; lack of instrumentation and centralized process control; and an occasional lack of telephones or other communication equipment to coordinate operations during industrial spills or plant upsets.

Glina (Bucharest) wastewater treatment plant

The Glina plant has been designed to treat an average daily flow of 22,500 liters per second (L/s) (514 mgd) and has been under construction for several years. Much of the civil works have been completed, and mechanical equipment is being installed. The plant contains three modules, two of which will be completed within the next two or three years. The plant will provide secondary biological treatment. The World Bank and the Bucharest water supply authority, RGAB, are conducting a study of the Bucharest water supply and wastewater system that will consider possible modifications or changes to the implementation schedule for the Glina plant.

Completion of the Glina plant is important for Romania, both domestically and internationally. The Dîmbovita and Arges rivers downstream from Glina are heavily polluted by raw sewage from Bucharest, and the effects are noticeable in the Danube for at least 30 km downstream from the mouth of the Arges. The Institute of Hygiene and Public Health has documented some of the effects of the pollution on potable supply systems along the Danube, where poor operation and control of water treatment plants place populations at risk. Romania is the recipient of pollution from upstream Danubian countries, and has been active in the formation and implementation of the Danube Environmental Program. To ensure the cooperation of the upstream countries in cleaning up the Danube, it is important that Romania provide wastewater treatment for its capital city.

Pitesti wastewater treatment plant

Pitesti's 2,200 L/s secondary treatment plant was developed in three stages, completed in 1967, 1972, and 1988. About half of the plant's flow comes from industry, including makers of textiles, wood products, beverages, milk, food, and leather products. No problems have been reported in biological treatment of the combined industrial and domestic flows, although the industrial pretreatment plants are reported to be overloaded. Major problems with the plant include poor flow splitting between the three flow streams because two flow streams share a single overloaded headwork, lack of sludge thickeners ahead of the sludge digesters, two disabled digesters, lack of sludge dewatering equipment, lack of transport equipment, and lack of a proper sludge disposal site. Formerly, digested dried sludge was spread at an agricultural cooperative farm. The division of the farm into small private farms has eliminated this option.

Cîmpulung wastewater treatment plant

The Cimpulung plant contains a small Imhoff tank that is out of service, and two modules (150 and 300 L/s capacity) providing secondary biological treatment. The plant receives flow from 11 industries, including the Aro car factory, a synthetic fibers factory, a pig farm, sausage factory, slaughterhouse, hospital, and two military camps where pigs are raised. Industrial flows cause several problems: fluctuations in flow and organic load from the pig farm; oils and heavy metals from the Aro plant; and detergents, foam, and ammonia from the fibers plant. Major problems with the treatment plant include frequent maintenance of blowers equipped with low-quality steel turbine blades; low BOD-removal efficiency; lack of sludge dewatering equipment; small area of sludge drying beds; and lack of a sludge disposal site until a municipal landfill site is selected.

The plant effluent into the Tirgului River receives very limited dilution, in proportions of about two parts river water to one part effluent. The nutrients and organics remaining in the effluent severely effect communities downstream. Mioveni relies on a bank-filtered water supply and is most seriously contaminated, with reported high levels of trihalomethanes (THMs) (in which organics interact with chlorination of potable supplies to create a carcinogen) and chlorinated phenols. The well supplies for Colibasi may also be affected.

Curtea de Arges wastewater treatment plant

This plant contains three modules: a 70 L/s Imhoff tank, and two secondary treatment modules of 80 and 120 L/s. The combined capacity of the three lines is estimated at 240 L/s, which is exceeded by average inflows of 280 L/s and peak flows of 400 L/s. High flows and suspended solids during wet weather also cause treatment problems. About 60 to 70 percent of the wastewater comes from industries that produce electronic parts, furniture, clothing, china, milk and dairy products, chicken, and beef. Major problems with the treatment plant include limited capacity (in basic treatment, blowers, sludge thickeners, and sludge drying beds); lack of mechanical dewatering of digested sludge; poor hydraulic flow splitting between the three modules; need for replacement of heat exchangers in the sludge digesters, and a shortage of spare parts.

The effluent into the Arges River passes through three reservoirs in succession before being used by the Pitesti water supply system. Intervening communities are supplied from wells, as is a downstream canning factory. Eutrophication and high nutrient levels are a problem in the downstream reservoirs, and occasionally in reservoirs upstream from Curtea de Arges, due to the organic load from leaves from the heavily forested watershed upstream from the Vidraru Reservoir.

3.2.3 Municipal Wastewater Emissions

Information on the 10 largest municipal discharges shows that their total flow in these major municipal systems is approximately 1.9 million cmd. More than 85 percent of the total wastewater discharged in the basin is from Bucharest and goes untreated. The flows from the municipalities of Pitesti, Cîmpulung, Curtea de Arges, and Gaiesti account for another 13 percent of the basin's total wastewater.

Much of the area's municipal wastewater is generated by industries that discharge into public sewer systems. The flow into the Bucharest system, for example, is estimated at approximately 50 percent domestic and 50 percent industrial.

Appendix B contains detailed water-quality data for municipal emissions in the basin. These data are summarized in Table 25. Data are unavailable for the untreated effluent from Bucharest; therefore, the BOD_5 is estimated at the design value of 165 mg/L, and the other parameters are estimated from the water quality in the Dîmbovita River at a point where the flow consists entirely of Bucharest wastewater. Total nitrogen values were available only for Pitesti's municipal emissions, which contain approximately 6 mg/L of total nitrogen.

The concentrations of BOD_5 in the effluent from the secondary treatment plants at Pitesti, Cîmpulung, Colibasi, and Curtea de Arges range from 50 to 80 mg/L, with phosphates between 1.2 and 0.33 mg/L, ammonia between 3.9 and 6.4 mg/L, and nitrate less than 1.0 mg/L. The plant at Buftea is overloaded, and the plant at Gaiesti is providing only primary treatment; this is reflected in the elevated BOD_5 concentrations in the emissions from these plants.

It should be reiterated that the quality of the aforementioned emissions data has not been confirmed, and that discrepancies exist between data sources. This possible lack of accuracy must be resolved in future studies. However, the inaccuracies were not deemed significant enough to affect the selection of priority projects for the basin.

Table 25

Municipal Emission Water Quality

ID Number	Description	BOD_5 (mg/L)	Phosphate (mg/L)	Ammonia (mg/L)	Nitrate (mg/L)
Bucharest	Bucharest WWTP	165	0.36	3.8	1.8
11-1	Pitesti WWTP	57	0.33	4.7	0.9
37-1	Cimpulung WWTP	56	1.07	6.4	1.0
4-1	Curtea de Arges WWTP	79	0.7	6.2	1.0
33-1	Colibasi WWTP	50	1.2	3.9	0.5
	Buftea WWTP	150		5.2	1.0
	Gaiesti WWTP	135	8.5	4.7	0.2
56-1	Topoloveni WWTP	79	1.18	8.9	0.7
12-1	Bascov WWTP	64	2.26	7.8	0.6
35-1	Maracineni WWTP	79	0.73	4.6	1.0

3.3 Industrial Wastewater Systems

3.3.1 Industrial Facilities

The WASH team visited several industrial sites to uncover general and specific information about industries in the area. A summary of the team's findings concerning industrial wastewater treatment facilities follows.

Dacia car factory, Colibasi

Wastewater from the Dacia car factory is discharged directly into the Tirgului River above Pitesti. Among other contaminants, metal finishing operations generate wastewater containing metals (including hexavalent chromium), phosphorus, and cyanide. The wastewater is treated at the factory in manually controlled processes to decrease the concentration of metals and cyanide. However, the treatment processes generate metal-containing sludges that are landfilled. In addition, spent plating baths are stored on-site. The main areas of need at this factory are automatic control of treatment processes such as pH adjustment, chromium reduction, and cyanide destruction; methods for the proper disposal or reuse of metal sludges and spent plating baths; minimization of waste; and implementation of measures to prevent chemical spills, and development of contingency plans should spills occur.

Aro car factory, Cîmpulung

Wastewater from the Aro car factory is discharged to the Cîmpulung municipal wastewater treatment plant and the Tirgului River. The wastewater contains metals (such as chromium and cadmium), phosphorus, and cyanide from metal finishing operations. Treatment is performed at several treatment plants using manual equipment. As at the Dacia factory, Aro's treatment process generates metal-containing sludges that are landfilled on-site or sent to a metal reclaimer. The capacity of the reclaimer is limited; therefore, not all of the sludges are recycled. The Aro factory needs automatic control of treatment processes such as pH adjustment, chromium reduction, and cyanide destruction; methods for the proper disposal or reuse of all metal sludges and spent plating baths; centralization of treatment facilities; analytical equipment to measure metals in water with increased accuracy, such as atomic adsorption spectrophotometry; minimization of wastes; and implementation of measures to prevent chemical spills, and development of contingency plans should spills occur.

Arpechim petrochemical plant, Pitesti

ICIM has studied the emissions from the petrochemical portion of the Arpechim plant and may make its results available in the future. It appears that the emissions from this plant are very complex. Problems include eutrophication and oxygen depletion in the Dîmbovnic River, and complications with the disposal of sludge from biological treatment processes.

Currently, USAID is conducting a study of the plant's economic viability and whether it should continue to operate (see Section 5.1.1). Results of this study should indicate whether additional evaluation of the plant's emissions is warranted.

General needs in industrial wastewater pretreatment

The existing wastewater pretreatment and waste management facilities at most of the sites visited are aging and need major upgrading or repair. Expertise is available to operate and monitor complex waste management facilities at these factories, but additional training will be necessary for operation of new facilities.

The potential for spills and upsets of pretreatment processes in the basin is very large. Storage of spent plating baths and inadequate disposal of metal-containing sludges, for example, increase the probability of the uncontrolled discharge of metals and cyanides into waterways and municipal wastewater systems. Besides reducing the risk of spills, recovery of metals from spent plating baths and sludges would be economical.

Phosphorus-containing wastes are generated by the metal finishing operations at the Dacia and Aro car factories; however, quantitative data on phosphorus in these wastewaters is unavailable. The existence of other indirect industrial sources of phosphorus is indicated by the concentrations of phosphorus found in the effluent from municipal wastewater treatment plants.

The Arpechim plant is the largest industrial wastewater emitter in the basin; however, other studies are being conducted related to the economic viability and possible rehabilitation of this facility, and thus the WASH team chose not to study it for the purposes of this report.

3.3.2 Industrial Emissions

Table 26 summarizes the largest 62 industries in the basin by type, and Table 27 lists the name, flow, and location of these dischargers' emissions. The entire set of water-quality data is included in Appendix B. Figures 7, 9, and 11 in Chapters 6, 7, and 8 show the locations of the major direct and indirect emissions discharged in the municipalities of Pitesti, Cîmpulung, and Curtea de Arges.

As noted previously, the largest industrial dischargers that emit directly to the basin's rivers are the Arpechim petrochemical complex and the Dacia automobile factory. The concentrations of BOD_5 in their emissions near 60 mg/L for Dacia and 30 mg/L for Arpechim, and nitrates approximate 1 mg/L in all streams. The highest concentrations of BOD_5, ammonia, and phosphate come from animal farms, but the flows from these farms are generally low enough that resulting loading to the stream is low.

Several indirect dischargers emit wastewater to the municipal treatment plants. Data on these dischargers are incomplete and do not include all dischargers or measurements of all parameters of concern. The most complete data exist for Pitesti. In general, the emissions contain concentrations of BOD_5 of 100 to 800 mg/L and 3 to 50 mg/L of ammonia. Nitrates are typically below 5 mg/L.

Phosphate is of special concern because of the limited removal efficiency available in secondary treatment plants. Data for the industrial sources of phosphate to the Pitesti WWTP are given in Table 28. More than half of the phosphate discharged to the plant comes from the Divertex textile plant.

Table 26

Summary of Industrial Dischargers by Type

Industrial Code	Type of Industry	Flow (cmd)	Number of Dischargers
1	Coal mining	1,496	9
4	Petroleum and gas extraction	921	2
5	Chemical industry	8,932	6
8	Energy production	975	2
14	Miscellaneous food and beverages	2,986	8
17	Animal farms	789	3
25	Other—not classified	27,158	27
26	Oil refining	120,118	3
28	Metal construction - small and machine	19,808	2
Totals		183,183	62

Table 27

Industrial Dischargers in the Arges Basin

Discharge I.D. Number	Discharger Name	Total Flow (cmd)	Domestic Flow (cmd)	Industrial Flow (cmd)	River Name	River km
20-1	SC Arpechim SA	47,721	3,814	43,907	Dîmbovnic	89
20-2	SC Arpechim SA	44,318	0	44,318	Dîmbovnic	89
20-3	SC Arpechim SA	28,079	0	28,079	Arges	222
32-1	SC Automobile Dacia SA	18,592	0	18,592	Doamnei	9
32-2	SC Automobile Dacia SA	5,616	5,616	0	Doamnei	10
13-3	SC Rolast SA	5,162	0	5,162	Arges	232
15-1	SC Alprom SA	4,241	296	3,945	Arges	224
38-1	SC Aro SA	3,649	625	3,025	Tirgului	36
39-1	SC Grulen SA	2,458	690	1,767	Tirgului	36
17-1	SC Pitber SA	2,159	0	2,159	Arges	224
39-2	SC Grulen SA	1,660	0	1,660	Bughea	17
13-2	SC Rolast SA	1,512	0	1,512	Bascov	3
14-1	SC Rotan SA	1,397	340	1,058	Arges	224
54-2	SC Cimus SA	1,381	0	1,381	Argesel	45
38-2	SC Aro SA	1,216	0	1,216	Tirgului	45
58-1	SC Valahia	1,216	0	1,216	Circinov	3
13-1	SC Rolast SA	1,052	1,052	0	Arges	224
18-1	Cet Gavana	915	0	915	Arges	232
10-1	Grup Industrial Petrol	855	164	690	Arges	251
15-2	SC Alprom SA	822	0	822	Bascov	2
34-1	ICN Colibasi	811	477	334	Doamnei	2
54-1	SC Cimus SA	778	260	518	Argesel	44
8-1	SC Baiculesti	726	282	444	Arges	259
22-1	Complex Vinificatie	726	58	668	Arges	218
14-2	SC Rotan SA	597	0	597	Bascov	2

(continued)

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Table 27 (continued)

Discharge I.D. Number	Discharger Name	Total Flow (cmd)	Domestic Flow (cmd)	Industrial Flow (cmd)	River Name	River km
19-1	Hidroconstructia Arges	427	427	0	Arges	230
52-1	Seppl Stilpeni	395	247	148	Tirgului	14
65-1	Romsuin Test Oarja	395	395	0	Dîmbovnic	83
64-1	Ferma Porci Bradu	296	296	0	Dîmbovnic	90
45-1	Mina Pescareasa	296	296	0	Tirgului	33
25-1	Statiunea Bradetu	263	263	0	Vilsan	41
79-1	Filatura Musceleanca SC	263	33	230	Dîmbovita	173
6-3	SC Biotehnos SA	263	263	0	Arges	266
57-1	SC Componente Auto SA	263	0	263	Circinov	3
42-1	Mina Jugur	230	230	0	Draghici	14
5-1	Abator Pasari Si Iepuri	230	0	230	Arges	266
16-1	Trust Pomicol	203	203	0	Arges	232
43-1	Mina Godeni	181	181	0	Bughea	9
41-1	Mina Poenari	181	181	0	Poenari	4
44-1	Mina Cotesti	181	181	0	Bughea	7
46-1	Mina Berevoesti	132	132	0	Bratia	26
47-1	Mina Slanic	132	132	0	Bratia	25
28-1	Um Bascov	121	121	0	Bascov	3
21-1	CLF Stefanesti	101	0	101	Arges	223
48-1	Mina Aninoasa	99	99	0	Bratia	25
62-1	Ferma Porci Ciupa	99	99	0	Neajlov	122
51-1	SC Muscevit SA	80	0	80	Tirgului	21
23-1	Spital Valea Iasului	66	66	0	Iasului	4
29-1	Bat Bascov	66	0	66	Bascov	3
1-1	Cabana Cumpana	66	66	0	Arges	306
49-1	Mina Boteni	66	66	0	Argesel	34

(continued)

Table 27 (continued)

Discharge I.D. Number	Discharger Name	Total Flow (cmd)	Domestic Flow (cmd)	Industrial Flow (cmd)	River Name	River km
36-1	SC Agromec SA	66	0	66	Doamnei	7
2-1	Colonia Capatineni	60	60	0	Arges	292
26-1	Um Valea Ursului	52	52	0	Bascov	10
59-1	Spital Calinesti	52	52	0	Circinov	12
24-2	CLF Valea Iasului	47	0	47	Iasului	2
30-1	Distilaria Domnesti	46	0	46	Doamnei	45
53-1	Distilaria Clucereasa	44	0	44	Tirgului	5
27-1	Han Turistic Valea Ursul	33	33	0	Bascov	6
3-1	Motel Cerbureni	33	33	0	Arges	276
6-1	SC Biotehnos SA	0	0	0	Arges	266
6-2	SC Biotehnos SA	0	0	0	Arges	266
Totals		183,183	17,877	165,307		

Table 28

Industrial Phoshate Loading to Pitesti WWTP

ID No.	Name	Flow (cmd)	Phosphate Concentration (mg/L)	Phosphate Loading (kg/day)
13-1	SC ROLAST SA	1,052	0.12	0.1
14-1	SC ROTAN SA	1,397	4.40	6.1
15-1	SC ALPROM SA	4,241	0.30	1.3
17-1	SC PITBER SA	—	—	—
—	SC ARGESANA SA	3,456	0.24	0.8
—	SC NOVATEX SA	4,320	0.31	1.3
—	SC DIVERTEX SA	2,592	4.80	12.4
			Total Loading	22 kg/day

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3.3.3 Impacts of Discharges

The pollutants of major concern in the basin are BOD, ammonia (or nitrogen compounds in general), metals, cyanide, and phosphorus. (Data are inadequate to characterize the extent of contamination by synthetic organic chemicals and nonpoint sources of nutrients, solids, and BOD.) BOD-containing wastes are generally treated and discharged to a river or pretreated and discharged to municipal treatment plants that can mitigate a lack of pretreatment if they have sufficient capacity. Wastes that contain metals or cyanides cannot be adequately treated in the municipal treatment plants. Similarly, wastewaters containing phosphorus or nitrogen may not be treated adequately in the municipal plants. Excluding the Arpechim petrochemical plant, the Agentia de Mediului in Pitesti has identified wastes that contain metals and cyanides as the most important industrial wastewaters, specifically the wastewater from the Dacia and Aro car factories. Also of concern is the eutrophication caused by the discharge of phosphorus and nitrogen compounds. Eutrophication of drinking water supplies decreases the quality of the water and increases treatment costs.

Tables 1 through 12 in Appendix D list the cumulative loadings of various contaminants on the rivers in the basin. These tables are calculated using DEMDESS and assume that all contaminants are conservative.

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Chapter 4

INSTITUTIONAL AND FINANCING CONDITIONS

4.1 General

The material presented below is based upon information obtained through interviews at the ministerial and local levels, various A.I.D. and World Bank reports, and standard Romanian references. These were supplemented by field visits to the Pitesti, Curtea de Arges, Cîmpulung, and Oltenita municipalities, and several of the larger industries operating in the basin.

4.2 Legal Basis

4.2.1 General

Legislation pertinent to Romania's environmental and water resources sectors are summarized in Table 29. Various laws, orders, and decrees enacted after 1973 defined the activities in these sectors, and increased the responsibilities of various government institutions. However, the legal framework has established two preeminent institutions in the sector: the Ministry of Environment, now known as the Ministry of Waters, Forests, and Environmental Protection (MWFEP), and the Romanian Waters Authority.

Notable in the environmental sector is Order 170/1990 (not included in Table 29), which established the procedures for environmental reviews and approvals by the Ministry of Environment, followed by ordinances that specified environmental assessment requirements. Law 264/1991 established the former Ministry of Environment as the sector's lead ministry, with wide jurisdiction and overall responsibility for environmental management in Romania.

National responsibility for water resources was defined by Romania's first water law, 8/1974, which established the Romanian Waters Authority, or Apele Romane (AR), as the responsible institution. Subsequent laws and decrees pertinent to water resources culminated with Law 5/1989. AR is organized as a semi-autonomous, financially self-sufficient agency that has normative and administrative ties to the MWFEP.

A new water law is under preparation. Its enactment will dramatically change Romania's water resources management system.

The MWFEP's organization and its relationship to AR are shown in Figure 6. (These institutions' activities and responsibilities are discussed in Section 4.3).

Table 29

Environmental Legislation

Law or Decree	Coverage	Applicable (Sub-) Sector
9/1973	General	Established framework for environmental legislation for all media. Principles to be developed through specific laws.
8/1974 1/1976 414/1979 (Decree)	Water bodies	Established rules for protecting water bodies by restricting or limiting pollutant concentrations in discharges.
264/1991	Water bodies	Established fines for discharging pollutants in excess of standards.
Various (subsequent to 1973)	General	Established ministries and other agencies with responsibilities to regulate the environment within their operational areas. Included Ministry of Health, Agriculture, Forestry, and Chemical Industry, and the National Council for Science and Technology.
264/1991	General	Established Ministry of Environment, granting it prime responsibilities for all aspects of environmental protection.

4.2.2 Trends in Legislation

Romanian environmental and water resources management is in a state of transition. Several new laws are expected to be enacted in the next two years. The two new laws that will most affect the sector are the new environmental and water laws.

A new draft environmental law was submitted to Parliament in the spring of 1992. The draft legislation would streamline portions of the MWFEP's environmental monitoring and control system, and extend this system to cover additional media (air and soil). Parliamentary action on the legislation was delayed by the 1992 elections and formation of the new government. Adoption of the new environmental law is expected by mid-1993. The ministry, in anticipation of the law's enactment, has incorporated several procedural changes in the operations of its local inspectorates (see Section 4.3).

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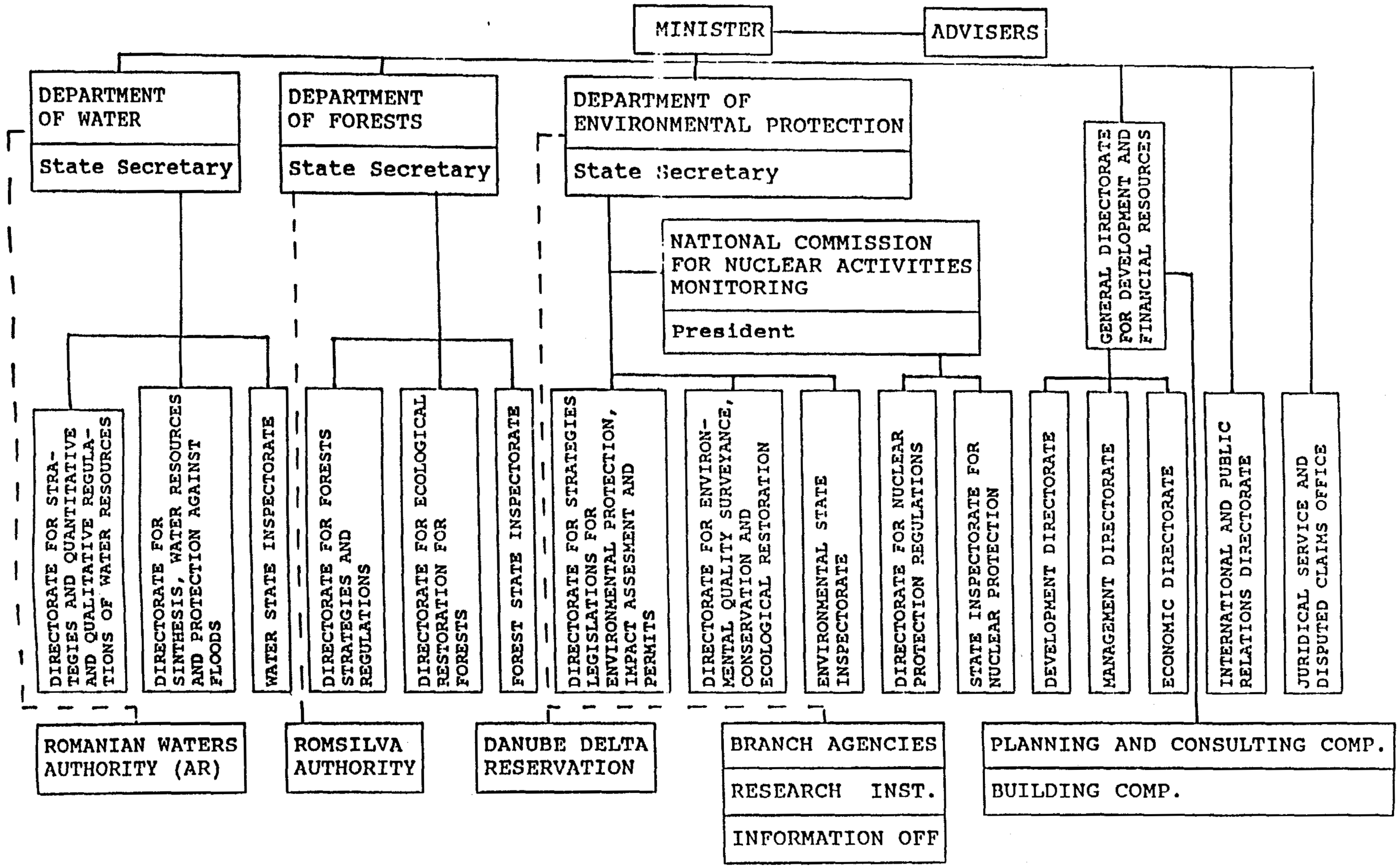

Figure 6

Organization Chart, Ministry of Waters, Forests, and Environmental Protection

Romania's new water law is in the early stages of preparation; parliamentary review is expected to commence later this year. The draft legislation indicates that very significant changes are forthcoming in the management of Romania's surface- and groundwater resources. The impact of the new water law can best be understood if one recognizes AR's existing mode of operation.

AR's operations are national in scope and are implemented through district offices in each of Romania's 14 major river basins. An important feature of its operational mandate is AR's ability to raise revenues through the imposition of charges for raw water extractions, and acceptance of discharges. AR's budget for 1992 was approximately 30 billion lei. Approximately two-thirds of the total was derived from the various charges AR imposed. The remainder was furnished by the central government, primarily as investment funding for flood control projects that provide multisectoral benefits.

The water law will establish, under AR's administration, river basin authorities in each of the 14 major river basins. These authorities, as prescribed by the new law, will be virtually autonomous entities with wide responsibilities to develop all groundwater and surface-water resources in their basins to ensure they are adequate in quantity and quality. The authorities will also be expected to help ensure the environmentally sound development of all water demands in the basin, including domestic and industrial water supplies, irrigation, and hydropower.

The draft water law requires each of the 14 basin authorities to prepare detailed, comprehensive basinwide plans for the short and medium term, to act as "blueprints" for the basin's development in terms of the adequacy of the quantity and quality of its water resources. Thus, these plans will include recommendations, construction schedules, and financing plans for all infrastructure and facilities (e.g., water and wastewater treatment plants, dams, dikes, levees, pump stations, and measurement and sampling stations) necessary for the river basin authorities to meet their responsibilities.

The new law specifically states that water supply and wastewater services are municipal responsibilities, and that facilities required to provide these services will be provided by the municipalities. Thus, the river basin authorities will not provide such services. However, under their water-quality maintenance responsibility, the authorities could require the renovation, upgrading, or new construction of wastewater treatment facilities. Similarly, they could limit or prohibit the direct discharge of nontreated wastewater from municipalities or industries.

The new draft water law also delineates a structure for the AR's schedule of fees, tariffs, and fines. The new law specifies that the levels of these charges will be set to reflect the authority's total cost of service. Further, the costs to be recovered will include a component representing 10 percent of the authority's assets. Revenue derived from this component of the charges will be deposited to a special environmental fund for use by the water basin authorities to finance construction projects. The draft law further states that the revenues derived by the individual river basin authorities are intended for use within that basin.

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In effect, the new water law as it is now conceived will almost totally decentralize water resources management in Romania. A single central authority will be replaced by 14 individual autonomous authorities, all with broad powers, with AR's responsibilities being limited to administration and coordination.

The new river basin authorities are tentatively planned to begin operating in 1995. Obviously, much must be accomplished in the next few years. It is also obvious that the MWFEP's mode of operation and activities will require changes to adjust to the new river basin format of water resources management.

4.3 Institutions Active in the Arges River Basin

Romania's environmental and water resources institutions and their responsibilities are summarized in Table 30.

Arges River Basin Regional Environmental Assessment and Management Inspectorate

A major component of the MWFEP's Department of Environmental Protection's operations (see Figure 6) are implemented through the inspectorates located in each judet. These 41 local inspectorates represent the department (and ministry) locally, and conduct a comprehensive program of sampling and laboratory analyses and other permitting and monitoring functions.

The inspectorates are organized by combining judets to cover the 14 major river basins in Romania. One inspectorate in each of the major basins is responsible for managing and coordinating the activities of all inspectorates in the river basin.

The inspectorate responsible for the Arges basin, officially named the Arges River Basin Regional Environmental Assessment and Management Inspectorate is known locally as the "inspectorate" and sometimes is referred to as "the local EPA." It is headquartered in Pitesti. The inspectorate's staff is very well known throughout the Arges River basin, as they are continuously involved in sampling and analyzing wastewater treatment plant discharges, industrial wastewater discharges to treatment plants and water bodies, and receiving waters. These data are used by the AR district office in its monitoring activities, and form the basis for assessing fines. The inspectorate's data are also furnished to ICIM for use in its work.

The inspectorate has 63 staff members in addition to the director and chief inspector. It is organized into five functional groups: Central Laboratory, Monitoring, Regulatory, Inspection, and Administration/Finance.

Table 30

Environmental and Water Resources Institutions

Institution	Responsibilities
Ministry of Waters, Forests, and Environmental Protection	Pollution and water-quality standards and monitoring.
Regional Environmental Assessment and Management Inspectorates	Pollution monitoring, sampling, testing, and environmental controls.
Romanian Waters Authority	Coordination of river basin management and sectoral planning for water-quality management.
River Basin Authorities	Implementation of water conservation management. ■ Flood protection ■ Water resources management ■ Water-quality management ■ Raw water sales and supply
Ministry of Health	Drinking water standards and monitoring.
Institute of Hygiene and Public Health	Sampling and testing of drinking water. Primary public health resource of the Ministry of Health.
Municipalities and Regional Enterprises	Implemention of water supply and wastewater treatment and other municipal services.

The Inspection group reports to the chief inspector, who functions as the director's chief assistant. All other group chiefs report to the director, who in turn reports to the state secretary, who heads the Department of Environmental Protection.

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In addition to the continuous program of sampling and analysis, the inspectorate is responsible for granting discharge permits and reviewing environmental assessments. Permits are required of public and private entities that discharge to surface waters. (The pending environmental legislation could require permits to include provisions for underground discharges, and air and noise emissions.)

Surface water discharge permits are granted on a case-by-case basis, based upon waterway classification and the constituent standards. Essentially, permits are granted on the principle of "nondegradation" in that the permit will be granted only if the new discharge will allow the waterway classification to remain the same. In reality, Category I waterways are never allowed to be degraded. In other rare cases, the inspectorate may, under extenuating circumstances, grant a permit recognizing the stream classification will fall to a lower level.

Environmental impact assessments (EIAs) are made, as per order of the minister, using the provisions of the pending environmental legislation. Almost all new development investments require an EIA. The investor or owner, whether a private enterprise, individual, or government enterprise, must have an approved EIA before its project can implemented. The "owner" of the project must have the EIA prepared by ICIM or another institute approved by the minister of MWFEP. The EIA must address the impact of the proposed project on water, air, soil, and noise.

After receiving the EIA, the inspectorate reviews it, sometimes doing additional research, and assesses its effects from a basinwide perspective. A "nonapproval" requires the project to be redesigned with added environmental controls. Ministry involvement in the EIA process is expected only for controversial projects, or in cases of great contention. EIAs for interministerial projects are also reviewed, with the inspectorate and or the ministry being the last agency to perform the review.

Arges River Basin Water Authority

This authority is one of the 14 river basin authorities that act as district offices of Apele Romane. As part of AR, the Arges water basin authority is responsible for implementing AR's responsibilities for water management and water-quality protection within the Arges watershed. The local basin authority also acts to collect the revenues derived from tariffs and fines from municipal and industrial entities. Tariffs are imposed on recipients of raw water and on wastewater dischargers. Discharges must meet standard parameter levels; if they do not, the discharging entity incurs a fine. Fines are also levied for excessive raw water extractions. (See Section 4.4 for further discussion of these points.)

Under the new water law, the nature of the river basin authorities will change substantially: their present status is as a district office of a national agency; their future status will be one of a semi-autonomous operating agency with broad responsibilities.

Municipal enterprises

Romania's municipal enterprises are autonomous organizations that provide integrated municipal services on a fee-for-service basis to households, industries, government installations, and other institutions within their service areas. They can exceed city boundaries, depending upon the particular enterprise's role. In the Arges River basin, municipal enterprises typically provide water supply and wastewater service (including treatment), solid waste (garbage) collection/disposal, and heat and hot water. The costs for these services are recovered from users via tariffs. The enterprises purchase their bulk water from AR.

The municipal enterprises in Pitesti, Curtea de Arges, and Cîmpulung also administer the sales of individual apartments in apartment blocks formerly owned by the government. (Prior to 1989, the enterprises arranged for the construction of the apartment blocks.) Half the money derived from a sale is sent to the Ministry of Finance, and the other half to the prefect of the judet, who is obliged by law to deposit such revenues into a development fund for use by the municipal enterprises as a source of capital investments.

The enterprises' housing sales activities are decreasing, as most individual housing units have now been sold. However, since many apartment purchases were based upon installment payments for 70 percent of the total price over several years (up to 15 years), related activity is still ongoing, with the prefect of the judet continuing to receive one-half of the collected proceeds.

The municipal enterprises charge fees for all services they provide, with industries paying higher rates than domestic or nonindustrial users. The enterprises are provided raw water through the local water basin authority, and pay the established tariff for this service. They also pay tariffs for the right to discharge wastewater, which they must do within standards. The enterprises are subject to fines if they exceed their agreed withdrawal limits and/or if discharges from their wastewater treatment plants exceed the national waterway standards. The enterprises, in turn, have the power to fine their industrial customers if the latter's wastewater discharges to the municipal treatment plant exceed the agreed-upon limits for discharges to sewer systems.

An important aspect of the enterprises' operations concerns their financial status. Romanian law allows the enterprises a profit margin of 5 percent; however, as economic agents, they are subject to a tax on their income.

Further, the municipal enterprises must function with balanced budgets. That is, the income they derive must cover all of their costs. If losses occur, they must somehow be covered. One method of doing so is to borrow from local banks; but interest rates as of early 1993 were between 70 and 80 percent. Thus, the "non-loss" requirement acts as a stringent financial control on the enterprises' operations. (Financial aspects of the enterprises' activities are discussed further in Section 4.5.)

From a program point of view, the municipal enterprises represent the most important local entity. Their service-provision responsibilities require that they properly operate and maintain

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their physical facilities. Romania's policy of decentralization requires the enterprises to provide future investment funds for new infrastructure, and to expand and/or rehabilitate the facilities related to their functions, including those comprising the water supply and wastewater systems, the thermal heating plants, and solid-waste assets.

The enterprises' basic responsibilities and functions may be greatly affected by the new legislation, especially the water law, being considered by the central government. These new laws will cause the levels of tariffs and fines to be increased. Furthermore, with the adoption of the pending environmental legislation and the organization of the newly empowered river basin authority, the municipal enterprises in the Arges River basin may be required to make investments for environmental control equipment and/or provide new or improved wastewater treatment facilities sooner than they expected.

Table 31 gives a sample of data typically available from the municipal enterprises in the Arges basin.

Other institutions

The prefect of judets and Ministry of Finance are also involved, in an administrative sense, in the environmental and water resources sector of the Arges and all other river basins in Romania. This relationship has to do with the financing of sector investments and is discussed in Section 4.5.

4.4 Regulatory and Enforcement Framework

The regulatory and enforcement framework in the Arges River basin refers to the activities of the inspectorate and the local river basin authority with regard to (1) checking emissions for compliance with relevant laws, ordinances, regulations, and standards; and (2) to imposing tariffs or fines, or taking other administrative action to control water use and water pollution.

4.4.1 Regulatory Activities

The regulatory activities in the Arges basin are divided between the inspectorate (for wastewater) and the river basin authority (AR). The inspectorate is responsible for granting permits to new industrial wastewater dischargers. The permits are granted subsequent to the inspectorate's study of the request, including, if required, the submission of an environmental impact assessment (see discussion in Section 4.3).

The local river basin authority issues permits for raw water extractions by domestic and industrial users. This activity is a component of the authority's responsibilities regarding the control of water resources.

Regulatory activities also include the local river basin authority's involvement in implementing the collection of tariffs for permitted raw water extractions, and of tariffs imposed for wastewater discharges that are within the standards. AR bases its imposition of wastewater tariffs and fines on the laboratory analyses the inspectorate prepares.

4.4.2 Enforcement Actions

Enforcement actions concerning wastewater pollution include the inspectorate's monitoring activities in the basin. The inspectorate performs laboratory tests to determine the levels of approximately 15 to 20 wastewater parameters in discharges to waterways. The discharges emanate from municipal and industrial wastewater treatment plants and domestic and industrial sources. Although testing industrial discharges to municipal wastewater treatment plants is a responsibility of the municipal enterprise, the inspectorate sometimes also performs these tests with the former's cooperation. A sample of the inspectorate's testing schedule for the Pitesti WWTP is shown in Table 32.

This testing program thus identifies wastewater constituents at concentrations above the standards. This in turn activates the local water basin authority's procedures governing the imposition of fines for excessive discharges.

In practice, the actual imposition of fines represents almost a "last resort" action. The municipal enterprises visited are very reluctant to move against industrial customers, due to Romania's poor economic situation. In fact, the local personnel of the Arges Basin Inspectorate indicated they are reluctant even to report discharges that exceed the standards. The explanation given for their apprehension was that the industries were experiencing very difficult economic times; thus, during this period of transition (by law, the full level of the fines will not be imposed until 1995), the inspectorates said it was better to work directly with the industries to improve their pretreatment works rather than to burden them further with an economic penalty.

Table 31

Selected Data for Pitesti Municipal Enterprise

Item	Value
Total population	201,500
Percentage served WS	100
Percentage served WW	95
Daily WS volume	182,000 cmd
Daily WW volume	156,000 cmd
Percentage of total WS provided to industry	25
Total number of employees	2,140
WS system employees	490
WW system employees	330
Water treatment plant capacity	216,000 cmd
Wastewater treatment plant capacity	190,000 cmd
1992 annual cost WS activities cost WW activities cost	3.796 billion lei 853 million lei 307 million lei
1992 revenue Revenue from WS activities Revenue from WW activities	3.958 billion lei 895 million lei 272 million lei
Apparent annual surplus (loss) All activities	162 million lei

Note: The above represent typical data that are available from the Arges basin's municipal enterprises.

Table 32

Pitesti WWTP Effluent Test Results, 1990–92

Parameter	Effluent Concentration in mg/L			
	Standard	1990	1991	1992[a]
Suspended solids	25	24.8	25.4	24.5
COD - Mn		43.4	45.0	46.7
COD - Cr	30	140	111	146
BOD_5	15	25.7	25.6	24.2
Ammonia	3.0	7.14	7.00	7.40
Nitrite	3.0	0.73	0.54	0.58
Nitrate	3.0	0.35	0.31	0.27
Hydrogen sulfide	0.1	0.088	0.060	0.023
Total phosphorus	0.1	3.29	2.25	0.84
Detergent	0.5	0.308	0.280	0.217
Residual oil	0.07	0.00	0.00	0.00
Chlorides	300	47.73	41.36	41.59
Total dissolved solids	1,000	224	252	248
Cyanide	0.01	0.00	0.00	0.00
Trivalent chromium	0.5	0.00	0.00	0.00

[a] Results are for January through September only.

A similar attitude was voiced by two of the four municipal enterprises visited. They willingly paid fines to the local water authority when the effluents discharged from their treatment plants exceeded standards. However, the enterprises chose not to pass along the fines to the known industrial dischargers at fault. They too cited the poor state of the economy as their reason for not passing along the fines. The municipal enterprises also pointed out that these industries are their biggest customers, as well as their neighbors. Thus, they say it is best to work with the various industries as required, to get things under control, rather than to penalize them. For similar reasons, no industry in the Arges basin has been closed due to water pollution, although the AR has the right to do this, subject to approval from the central government.

4.5 Financial Issues

Key elements of this report's financial analyses include the need for both operation and maintenance (O&M) and capital costs; availability of funds from various sources and the optimal mix of such funds; and the effects on system users of paying back any borrowed funds.

Based on this analysis, it is clear that sources of capital financing for the Romanian wastewater sector are at extremely low levels compared with the costs of improvements required. Because of the country's depressed economy, the central government has drastically reduced its contributions to municipalities for capital construction funding. This is extremely significant, as prior to 1989, the government was the sole provider of significant funds for public works financing. Furthermore, such funding was extended on a contribution, or grant, basis, meaning that the municipal enterprises were not required to pay them back.

Because of the problematic funding situation in Romania, it is difficult to present a meaningful "standard" financial analysis for this study. The format of this section therefore concentrates on presenting a detailed discussion of the financial issues and the alternative sources of financing that may be worth considering.

4.5.1 Issues

Infrastructure financing is an enormous concern for the public officials involved in the sector, especially those at the local level. They recognize that the operations of the municipal enterprises are becoming more and more expensive, and they anticipate even greater rates of cost increases in the next several years, especially if they are expected to fund new capital construction. At the same time, the enterprises have virtually no access to external funds, leaving monies derived from tariffs and fines as their only sure source of revenue. System users are limited in their ability to pay continuously increasing tariffs for service and may become overburdened if payback of high capital costs is included in the tariffs. These issues are discussed further below.

Municipal enterprise operations

Romanian municipal enterprises are required by law to be financially self-sustaining. These tariffs must generate enough revenue to cover all the enterprises' costs, because deficits, even in the short term, are illegal. Typical tariffs for water supply and wastewater service for three enterprises in the Arges basin are shown in Table 33.

In the past, investment funding was provided by the central government. Now, however, the enterprises are concerned that they may be faced with having tariffs and fines as their only source of revenue to cover both operating and capital costs.

National economic situation

The poor situation of Romania's economy and the country's drastic inflation rate have had a greatly adverse effect on the budgets of municipal enterprises. Obviously, the costs of goods and services the enterprises purchase are increasing against relatively fixed revenue from tariffs (once tariffs are set they cannot be changed for at least six months). Further, the enterprises are subject to salary indexing: increases to staff salaries are mandated by the central government, and substantial increases have been granted six times over the last 18 months. Given these conditions, currently it is impossible for the enterprises to establish a realistic budget and thus set a justifiable level for tariffs.

Water authority charges

The Apele Romane schedules of tariffs and fines shown in Table 34 should substantially increase by 1995, as the new water law will change the basis for setting these charges. Furthermore, these charges will be increased to include a surcharge to finance the new environmental fund. Thus, under the new water law, the municipal enterprises face higher charges for water-quality maintenance and resource use.

Availability of capital funds

The availability of government funds for capital construction has decreased drastically during the last several years. In effect, government-financed new construction in the national wastewater sector has, except for selected projects started prior to 1990, come to a halt. Additionally, the state of the national economy provides little encouragement, and no significant commitments of external aid have been made. The ability of system users to pay the full cost of service, if capital costs are included, is extremely limited (see "Ability to Pay," below, for more on this subject).

Table 33

Water Supply and Wastewater Tariffs for Three Municipal Enterprises in the Arges Basin

Municipal Enterprise	Type of User	Type of Tariff	
		Water Supply	Wastewater
		Lei per m^3	
Pitesti	Domestic	5.90	1.65
	Industrial	31.0	12.05
Curtea de Arges	Domestic	7.6	2.6
	Industrial	27.0	13.10
Cîmpulung	Domestic	7.0	1.50
	Industrial	15.5	8.50

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Table 34

Apele Romane Schedules of Tariffs and Fines

(A) Tariffs for Raw Water Withdrawals and Wastewater Discharges

Category of Tariff	Water Use or Wastewater Discharge Type	Units	Tariff (Lei) per Unit
Raw water withdrawals	Industrial	1,000 m^3	1,534
	Domestic and other non-industrial	1,000 m^3	532
Wastewater discharges with concentrations within standards	Suspended solids	Ton	508
	Oxygen-demanding material	Ton	2,052

(B) Typical Fines for Wastewater Loads Exceeding Limits

Parameter Discharged in Excess of Standard	Fine for Loads in Excess (Lei/kg)
Suspended solids	1.03
BOD_6	4.12
COD-Cr	2.06
Nitrates	2.06
Chloride, sulfate, manganese, sodium, calcium	1.55
Ammonium, nitrites	10.30
Trivalent chromium, iron, detergents	20.6
Ammonia, phosphorus, manganese, nickel, residual oil	61.8
Hexavalent chromium, lead, zinc, copper, H_2	206
Cyanide	618
Residual or free chlorine	824
Cadmium, phenols	1030
Carcinogenic compounds	51,500
Mercury and extremely toxic compounds	123,600

Ability to pay

Inherent in all analyses of sector financing is the ability of the system users to pay for the services they receive. It is inappropriate to provide programs that will place undue financial burdens on the people or industrial enterprises these programs are designed to benefit. The ability to pay (ATP) discussion presented in this section is brief because it is intended to convey simply the sense of the issue involved, rather than to develop definitive cost functions or to measure relative impacts on various system users.

Ability to pay is obviously affected by income. Romania's National Statistics Board, in a January 1993 report, estimated that the average monthly wage in the country's urban areas was 27,763 lei. This value was more than twice the value for January 1992; however, the board estimated that due to a rise in consumer prices, the January 1993 wage level represented a loss in real wages of about 23 percent over the previous year.

Referring to the municipal tariffs shown in Table 33, and considering various statistics on water and wastewater service levels and the number of customers in each system, most individual domestic households (assuming each household was billed separately) would be billed approximately 100 lei to 300 lei per month, for both water supply and wastewater service. If the domestic water supply consumption in the urban areas of the upper Arges River basin is somewhat proportional to income, these charges should pose no problems for even the lowest-income portion of the salaried work force.

The effect on monthly household payments when repayment of hypothetical capital costs is included is illustrated in Table 35. Investments are assumed to be repaid over a 20-year period at interest rates of 12 to 20 percent. The present interest rate in Romania exceeds 70 percent. Thus, the interest rates in Table 35 are illustrative of a future condition when inflation will have been reduced, or as a net interest rate after subtracting the effects of inflation. The 12 percent interest rate shown can be thought of as a benchmark level of a market rate that could be used as the basis for external loans.

The monthly values in Table 35 when compared with the approximate distribution of monthly wages indicates the following:

- For a large system similar to the Pitesti wastewater system, an investment (loan) level of about 5 billion lei (approximately $US 9 million at the March 1, 1993 conversion rate) might be financed with monthly household payments of 611 lei. The latter figure represents 3 percent or less of monthly wages for about 85 percent of wage earners.

- For a small wastewater system serving about 30,000 people, the investment level that might be financed with monthly household payments representing 3 percent or less of monthly wages, for about 85 percent of wage earners drops to about 2 billion lei (approximately $US 3.5 million).

It is difficult to pinpoint how investment levels of 2 billion to 5 billion lei would fit the pollution control needs of the Arges River basin. Furthermore, the above analysis is rough and assumes market interest rate levels that cannot be shown as valid under the present turbulent economic

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circumstances. However, the significant point to be made is that a reasonable level of investment that is fully self-supporting can be made for wastewater systems in the Arges River basin, within the customers' ability to pay. The key variable appears to be the rate at which the economy stabilizes.

4.5.2 Sources of Financing

A source of significant capital financing for wastewater infrastructure in the Arges River basin may not be available without external support. This section summarizes several possible financing sources, and the issues associated with them.

Possible sources include the following:

- receiving grants from the central government;
- borrowing from the central government at preferred interest rates;
- borrowing from the proposed environmental fund established under the new water law;
- borrowing from a fund that is established using the proceeds of external loans or grants;
- self-financing; and
- a combination of the above.

The issues associated with these various possibilities are discussed below.

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Table 35

Example of Capital Cost Repayment

MONTHLY PAYMENT PER HOUSEHOLD
TO REPAY VALUE SHOWN WITH
INTEREST RATE PER ANNUM AS SHOWN (2)

COST TO BE REPAID (Million Lei)	12 %		18 %		20 %	
	CASE A	CASE B	CASE A	CASE B	CASE A	CASE B
100	12	31	17	43	19	47
200	24	61	34	85	38	94
300	37	92	51	128	56	141
500	61	153	85	213	94	234
1,000	122	306	171	427	188	469
2,000	245	611	341	853	375	938
5,000	611	1,528	853	2,133	938	2,344
10,000	1,223	3,057	1,706	4,265	1,875	4,689
20,000	2,445	6,113	3,412	8,531	3,751	9,377
50,000	6,113	15,283	8,531	21,326	9,377	23,443

Notes: (1) Pitesti ww system, Case A in the table has approximately 42,000 households. Case b, the smaller system, has 8,000 households.

(2) For the example, capital cost values shown are assumed to be paid back in eqaul annual installments, over a 20 year period, at the annual interest rates shown.

Grants from the central government

As noted previously, prior to 1989, all capital funds to the sector were provided through the central government. Then as now, the Ministry of Finance (MOF) was the government agency that ultimately disbursed the funds. Now, the ministry also acts as the initial contact in the process required to obtain such funds, but before 1989, the MOF and the State Committee for Planning were involved, and approved projects were made part of the government's five-year plan. Project implementation was thus centrally controlled in a rigid manner.

The MOF now functions alone, without the benefit of any sectorwide plan. Thus, for a municipal enterprise to obtain funds from the MOF, a great deal of persistence is required. According to several municipal enterprise staff members the WASH team interviewed, a great deal of luck is involved as well. Furthermore, the level of funding available for nonministerial institutions is modest at best.

Nevertheless, the MOF does provide a modest amount of capital for sector investments each year. The WASH team estimated the amount of these disbursements by examining the 1992 value of investment capital provided for agriculture, silviculture, water resources, and the environment. This value was about 217 billion lei, or, on a national basis, approximately 9,500 lei per person. (By comparison, the amount provided for local budgets, mainly to cover operating costs, was about 7,500 lei per person.) Apele Romane officials indicated that of this 217 billion, their budget included only 10 billion lei for capital construction throughout the country for water resources development.

With Romania's economy showing few signs of recovery, it is doubtful that national wastewater sector allocations will increase substantially in the next several years. Thus, if any direct government grants are available, they will be at relatively low levels. However, the municipal enterprises should continue to monitor the MOF as a source of funds.

Borrowing at preferred interest rates

Borrowing from the government at preferred interest rates (interest rates lower than the commercial market rate) means the government absorbs the loss equal to the difference between the interest it receives from the borrower and the higher interest rate it pays. The government payment thus acts as a subsidy.

The market-based interest rate in Romania, as previously noted, is enormous—approximately 70 percent per year. It is impossible to imagine any entity borrowing at this rate for any more then one or two months, unless the long-term capital amount owed and the interest rate paid were keyed to an inflation index. It is probable that such borrowing cannot occur until the net interest rate (after inflation) drops to levels below 15 percent. While no reliable estimates are available as to when capital markets will mature and establish ways of grappling with inflation, it is safe to say that undoubtedly several years will pass before interest rates drop to 15 percent.

Special environmental funds

Borrowing from the proposed environmental fund expected to be established under the new water law appears to offer an attractive financing option. However, it must be recognized that this fund does not yet exist. Even if the new water law is enacted in the first half of 1993, the law requires that implementing regulations be formulated in one year. Additional time will be required for the amount in the fund to reach a significant level.

One must also consider the "political" characteristics inherent in such national funds, especially those established for use by new agencies (that is, the new water basin authorities). Legislators, judets, and municipalities will exert enormous pressure to have funds allocated or be accessible to their particular constituencies. Thus, there is no way to predict the allocation or accessibility levels of such funds for the municipal enterprises. It seems likely, then, that any significant disbursement from the proposed environmental fund to finance wastewater infrastructure is several years away.

External assistance

Borrowing from a fund established from the proceeds of loans or grants provided through external assistance is a classic method for financing infrastructure. This method appears to offer the "cleanest" and fastest method for Romania's wastewater sector to obtain capital financing. The World Bank, EBRD, and USAID have made recent investments in the sector for water-quality studies (including this study) as part of the Danube Environmental Project. The international financial institutions have expressed an interest in maintaining their involvement in the environmental sector; however, they have made no commitments so far to provide significant levels of investment funding in Romania, outside of Bucharest.

Several issues are associated with borrowing from the World Bank or EBRD. For one, the government would probably have to guarantee repayment. The terms of the loan—the amount, the items of expenditure to be covered by the loan, the interest rate, years to repay, and the grace period—would be subject to negotiation between the banks and the government. The most serious issue by far concerns the "on-lending" interest rate. The banks ordinarily loan funds at rates pegged to some international standard, or to levels they set by policy. These interest rates are normally about 9 to 11 percent.

However, as a rule, the banks require as a stipulation of the loan agreement that any loans made from these funds to third parties (as in the case of on-lending from the central government to a municipal enterprise) be made at the commercial rates existing in the country. This stipulation is made so that bank loans will not act to distort the local economic situation. If this stipulation is insisted upon, it would likely be several years before Romania's interest rates are low enough for the municipal enterprises to afford.

Self-financing

Self-financing connotes that some percentage, in some cases up to 100 percent, of the funds needed for project financing are provided via local revenues. Such revenues sometimes are accrued over several years in reserve accounts.

Examples of local revenues are those obtained through user tariffs, taxes, special assessments on users, and connection fees. (The last two are popular in North America.) Lump-sum payments are provided by the system's users, and the combined payments are used to finance new construction or extensions to existing systems.

The most popular method of project financing in North America is the sale of bonds that are paid off, with interest, by the tariffs collected by the agency providing the service. In effect, securities are sold at prescribed interest rates, and for set periods of time. The security buyers are paid interest until the security is redeemed (repurchased by the enterprise). This type of financing can only be employed if the country's banking system is well developed and prevailing market interest rates are reasonable.

Self-financing for portions of projects in the Arges River basin is logical to consider. However, some important points must be examined before adopting this strategy, including the users' ability to pay and the lack of taxing power at the local level in Romania (all taxing power lies with the central government). Taxes collected at the municipal level currently must be turned over to the Ministry of Finance, which in turn provides the municipal budget. There is no indication that this situation will change in the next several years.

4.5.3 Conclusions

Financing wastewater facilities in Romania requires the resolution of many complex economic and political issues; in the country's current state of change, many options are available, but no solutions are clear. Solutions can emerge only as Romania's economy improves and a firm program for wastewater infrastructure development emerges. Perhaps wastewater plans will stem from the river basin authorities' basin planning efforts, as anticipated under the draft water law. In all likelihood, however, a comprehensive program of wastewater facilities construction in the Arges River basin will not commence in the immediate future.

On the basis of the observations and data cited above, the WASH team has made the following conclusions:

- No "magic" method is available to obtain capital investment funds for Romania's wastewater sector, and in the short term very few investments in infrastructure can be expected. The responsible institutions should identify the sector's critical requirements and continue their lobbying efforts to obtain government or external assistance to remedy these situations.

- The development of an effective sector financing strategy will require a concerted effort by the many institutions involved, to devise the optimal combination of the financing mechanisms ordinarily used for such projects. The most significant issue in this regard, at least for funding in the short term, may be the availability of external assistance. If this source of funding is pursued, a major constraint would be the lending banks' usual policy of stipulating that loans to the national government be on-loaned at the prevailing commercial market interest rates.

- Tariffs will undoubtedly increase. The entire issue of tariffs is sensitive and politically charged. Officials should only pursue tariff increases when they can make a clear case to their customers for them. This in turn may require an improved level of service.

Chapter 5

POTENTIAL PROJECTS

5.1 Issues in Identifying Projects

5.1.1 Technical and Economic Issues

Major technical and economic issues the WASH team identified in the course of this study are discussed below. These topics may require future study to resolve. The purpose here is to state the various assumptions that have been made in identifying the components and scope of potential projects.

The need for nutrient removal in municipal treatment plants to reduce eutrophication

Tertiary wastewater treatment to remove nutrients (nitrogen and phosphorus compounds) is expensive in terms of both capital and operating costs, which in turn has an impact on the economic and financial feasibility of a wastewater treatment project. Yet some form of nutrient removal at municipal plants is assumed necessary to identify potential wastewater project investments, but this assumption is by no means clear-cut.

Many other technical options to mitigate problems caused by nutrients in the stream could also prove cost-effective, such as the following: improving control of the few industrial discharges that contain high concentrations of nutrients (such as from phosphate detergents used by the textile plant in Pitesti, and from the use of phosphoric acid in metal plating operations at the car factories); eliminating the artificial lakes on the Arges River between Pitesti and the Bucharest intake at Ogrezeni (to eliminate the habitat for suspended algae); allowing or promoting the filling of the lakes by sediments, which is occurring at a relatively rapid rate; removing nutrients by covering the lakes with floating plastic cells to grow harvestable duckweed; dredging nutrient-laden sediments from the reservoirs and/or covering the sediments with inert fill; and using controls or economic disincentives to reduce the use of inorganic fertilizers on agricultural land, to limit the entry of nutrients from nonpoint-source runoff.

Each of these options poses its own set of data gaps, and its own set of limitations in one's ability to model natural processes such as eutrophication, chemical balances, and dissolved-oxygen demands in river systems.

The WASH team assumes that nutrient removal (specifically for phosphorus) is required within the upper portions of the Arges basin, in order to protect the Pitesti and Bucharest water supplies and to improve environmental amenities in the artificial lakes and the downstream portion of the Arges River.

The primary evidence indicating a need for point-source control of nutrients is the fact that eutrophication has been a problem in the Arges basin only in the last 10 years, and that the Pitesti plant's operating data show high levels of phosphorus over the last 3 years. It has also been reported that the artificial lakes downstream from Curtea de Arges have eutrophication problems that are much more severe than those in the Vidraru Reservoir.

In addition to controlling eutrophication, further removal of ammonia, nitrate, and phosphate in the municipal plants in Pitesti, Cîmpulung, and Curtea de Arges would have a number of other advantages:

- Removal of ammonia would protect fish in the river and in downstream artificial lakes.
- Removal of nitrates would reduce health risks in the Pitesti and Bucharest drinking water supplies. In Romania as a whole, chemical fertilizers are manufactured primarily for export rather than local use, while farmers in the Arges basin reportedly rely on natural organic fertilizers, which are less harmful. However, the levels of effluent dilution available within the Arges are low, and soluble nitrates are very difficult to remove in a potable water treatment plant. Additionally, chlorinating algae-laden raw water to disinfect it can create THMs, which are carcinogenic.
- Phosphorus removal would be the critical feature in controlling eutrophication, and would probably involve chemical precipitation and settling or filtration of the biologically treated effluent. Such advanced effluent treatment would provide an improved barrier to discharges of industrial heavy metals and toxins, and reduce the concentrations of coliforms and other bacterial contaminants in the effluent (since disinfection of effluent by chlorine or ozone is not practiced in any of the European countries). Reliable operation of a tertiary plant could thus provide assurable health benefits to downstream users, particularly for bank-filtered water supplies, as found in Gaiesti.

Assessment of risks to public health

Heavy metals and toxic organics from industry can pose a risk to the public health, but laboratory equipment available in Romania is generally incapable of detecting these pollutants. Relevant statistics on public health are lacking for the types of cancer and other effects generally attributed to heavy metals and other toxins.

A comparison of the magnitude of streamflow and wastewater within the basin, and an appreciation of the magnitude of industrial activity compared with the limited assimilative capacity of the basin, indicate a serious risk to public health. Total wastewater generation in the basin (during the daytime period of industrial operation) exceeds 28 m^3/s, of which about 18.5 m^3/s is the wastewater flow from Bucharest. In the absence of regulating reservoirs to maintain adequate streamflows for Bucharest's water supply, the naturally occurring low flow of the Arges River at the Danube is only 25 m^3/s, and the average streamflow is only 65 m^3/s.

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Thus, projects to improve wastewater pollution control in the upper basin would reduce health risks, but data on effluent and in-stream water quality are lacking that would allow difinitive ranking of such projects based on health risks (such as establishing different priorities for improvements at Pitesti, Cîmpulung, or Curtea de Arges).

Reduction of risk from industrial spillages

Current data do not indicate high heavy-metals concentrations in the wastewater from area industries; however, the use of toxic and hazardous materials in industrial activities represents a possible risk of exposure to the general population if spills or improper disposal occurs. Training in spill control and contingency planning for industries and local inspectors is needed in addition to facility modifications. Also, a central facility to reclaim metals from metal-finishing sludges would provide a useful service to many of the platers and electronics manufacturers in the area, while reducing the risk of spills and leachate from the disposal of metal sludges. In general, improvements in the analytical capabilities at industrial plants are needed to support pretreatment activities. The WASH team has assumed that industrial activities or programs of this kind can be implemented, and that the audience for this report is appropriate to promote them.

Economic viability of industry

The transformation of the Romanian economy away from its previous reliance on heavy industry toward light industry and services, and the imposition of true economic costs for industrial raw materials and energy, may result in the failure of certain industrial enterprises. The Arpechim petrochemical plant is a possible case in point.

When visited during the first WASH Danube study in February 1992, the Arpechim plant was running at about 60 percent capacity. In October 1992, it was down to about 30 percent. USAID is currently sponsoring a study of the petroleum sector throughout Eastern Europe to identify the more efficient petrochemical plants that should remain in operation.

Although the Arpechim plant is a major source of pollution, resulting in the death of the Dîmbovnic tributary, its wastewater obviously cannot affect Bucharest's water supply. Any improvements in end-of-pipe wastewater treatment must be considered carefully, since the longer-term viability of the plant will require major investments in improved operation, maintenance, and technology for petrochemical processing, and such technology would be less polluting. Thus, imposing heavy costs for wastewater treatment before the plant is modernized could prove counterproductive and ultimately cause the plant to close. Therefore, a "wait-and-see" passive approach to wastewater investment in Arpechim appears warranted. USAID may provide technical assistance to Arpechim in waste minimization using WEC (World Environment Center) expertise, which would be a desirable first step in reducing pollution from Arpechim.

For industries discharging into municipal wastewater systems, a more active approach is warranted. Improvements in municipal treatment can be balanced in a least-cost trade-off with improvements in industrial pretreatment, and the costs for new municipal facilities can be shared with domestic users, cross-subsidized by industry. Additionally, municipal plants can act, to a limited extent, as backstops to industrial spills or poor industrial pretreatment.

Combined-sewer overflows

Several topics related to combined-sewer overflows have not been investigated to date, and are assumed to be of limited relevance. These include the extent to which solids are deposited in combined sewers; the buildup of heavy metals and organics in these solids; and the frequency and composition of combined-sewer overflows. Although wet-weather overflows may be contributing to pollution of the basin's rivers and artificial lakes, and may pose health risks, consideration of the combined-sewer overflow problem should be relegated to a later stage of the pollution control planning process. Studies of combined-sewer overflows are generally complex and time-consuming and all too often have not resulted in a clear and reliable program of capital improvements and operational requirements (such as more frequent street sweeping). Thus, solving potential problems with combined-sewer overflows need not be addressed in these pre-investment studies.

5.1.2 Financial and Institutional Issues

The development of a long-term plan for water-quality improvements in the Arges basin is hampered by a number of factors, as outlined in Chapter 4 of this report. Still, many of the country's current financial and institutional problems are being addressed by municipalities and industry, and notable progress is being made in decentralizing responsibilities to local levels of government. Several issues considered critical to devising a long-term plan are outlined below.

Sources of capital funds

Sources of funding for municipalities are limited at present to grants from the central government. Yet, as described in Chapter 4, the prospects for obtaining funds in this manner are limited. Raising funds locally will be very difficult in the next three to five years; low salary levels and the decline of heavy industry will require time for the economy to adjust and rebound. Consequently, although the principle of "the polluter pays" may be viable in the long term, it seems clear that external loans will be needed in the interim, whether by grants or low-interest loans from the central government, or grants or loans from international donors or lenders.

In order to prepare a long-term plan, establishing ground rules for a financial analysis would be helpful. These include such items as the likely grace period, interest rate, coverage (of foreign-currency costs, local costs, or both) of loans, and minimum size of project that might be considered by EBRD or the World Bank. The extent of any improvements in water quality will be tightly linked to the affordability of the fees and tariffs to domestic and industrial users; these in turn are linked to conditions imposed by lenders.

Enforceability of environmental regulations

The Dîmbovnic and several other tributaries are polluted by salty water from oil recovery operations. Officials in the Arges environmental inspectorate have indicated that they can assume responsibility for solving this problem, which can be attributed in part to poor operations by personnel at the state petroleum enterprise. At present, the level of fines is too low to motivate the state petroleum enterprise to discontinue its detrimental practices. On the basis of this information, the WASH team chose not to pursue detailed information on the nature of this problem, or on its possible solutions.

5.2 Prioritizing Potential Projects

5.2.1 Candidate Projects

In order to solve the water pollution control problems in the Arges basin, the following construction or rehabilitation projects (summarized in Table 36 have been identified:

- Bucharest: Completing the Glina biological wastewater treatment plant (which receives about two-thirds of the total wastewater generated in the Arges basin), and improving control over pretreatment of industrial wastewater (from a variety of industries representing about 18 percent of national production).
- Pitesti: Upgrading and modifying the existing biological wastewater treatment plant, primarily for improved sludge processing and disposal, and the eventual provision of nutrient removal processes; reducing the source of industrial wastes; and improving control over pretreatment of industrial wastewater (representing about half of the total flow, from industries that include makers of textiles, wood products, beverages, milk, food, and leather products).
- Cîmpulung: upgrading and rehabilitating the existing biological wastewater treatment plant, to include the eventual provision of nutrient removal processes; and improving control over pretreatment of industrial wastewater (including flows from the Aro car factory, a synthetic fibers factory, a pig farm, a sausage factory, slaughterhouse, and hospital).
- Curtea de Arges: expanding, upgrading, and rehabilitating the existing biological wastewater treatment plant, to include the eventual provision of nutrient removal processes; reducing the source of industrial wastes; and improving control over pretreatment of industrial wastewater (from industries producing electronic parts, furniture, clothing, china, milk and dairy products, chicken, and beef).
- Arpechim petrochemical plant in Pitesti: implementing the findings from a three-year investigation by ICIM (the Research and Engineering Institute for the Environment) on segregation and treatment of three waste streams from about 35 pretreatment facilities within this large, complex industrial facility;

- Dacia car factory in Colibasi and the Aro car factory in Cîmpulung: improving control for treating wastes containing heavy metals, phosphorus, and cyanide; improving recovery of metals from sludges and spent plating baths; and improving waste minimization and sludge disposal.

Table 36

Potential Projects

Problem Area Description	Contaminants	Approximate Population in Area	Potential Projects	Financial Details
Municipalities				
Bucharest	■ Organics ■ Nutrients	2,100,000		The World Bank is funding a study of the water and wastewater systems for the city.
Pitesti	■ Nutrients	180,000	■ Sludge management improvements ■ Headworks expansion ■ Nutrient removal ■ Industrial wastewater pretreatment program	Funding has been from the central government; however, the economy is now very weak and outside loans will probably be needed.
Cîmpulung	■ Nutrients ■ Organics	44,000	■ Sludge management improvements ■ Flow equalization ■ Improved biological process ■ Nutrient removal ■ Industrial wastewater pretreatment program	Funding has been from the central government; however, the economy is now very weak and outside loans will probably be needed.
Curtea de Arges	■ Nutrients ■ Organics	33,000	■ Sludge management improvements ■ Headworks expansion ■ Flow equalization ■ Improved biological process ■ Nutrient removal ■ Industrial wastewater pretreatment program	Funding has been from the central government; however, the economy is now very weak and outside loans will probably be needed.
Industrial				
Arpechim petrochemical plant	■ Organics ■ Phenol			The future of this plant is uncertain. It is currently operating at 30% of capacity. ICIM has data on treatment plants and effluent characteristics.
Dacia car factory	■ Metals ■ Phosphorus ■ Cyanide		■ Improved treatment ■ Metals recovery ■ Waste minimization ■ Spill planning	
Aro car factory	■ Metals ■ Phosphorus ■ Cyanide		■ Improved treatment ■ Metals recovery ■ Waste minimization ■ Spill planning	

5.2.2 Prioritization

The potential projects described above can be prioritized using a variety of criteria, including elimination of health risks, affordability, speed and ease of implementation, readiness to proceed, viability of industry, economic impacts, and cost-effectiveness. However, such criteria are difficult to apply quantitatively and objectively, and arriving at a total "point score" for comparisons is difficult when the criteria are expressed in different, incommensurate units (such as lives saved, increased longevity, user fees representing a lower percentage of disposable income, and so on).

For the purposes of this report, a high-priority project was defined as a project that was to receive more detailed investigation as part of the current WASH pre-investment study. An important consideration is that high-priority projects are those that are not being studied by other donors that are of potential interest for further study and possible investments by the donor community.

Those projects that are unsuitable for inclusion in the high-priority list are as follows:

- The Bucharest water supply and wastewater system is to be studied under a World Bank project, for which the consultant has been selected by RGAB (the Bucharest water and wastewater authority). Construction on the Glina plant has proceeded in recent years despite the economic hardships in Romania and will probably continue until two of the facility's three treatment modules are placed in operation. Thus, it is unnecessary to consider the Bucharest wastewater system in the listing of high-priority projects for the current study.

- The Arpechim petrochemical plant in Pitesti is a major source of water pollution, but the economic viability of the plant is open to question. The plant was built in the 1960s and requires modernization of its basic production processes. Improvements in the facility's wastewater treatment processes must therefore be tied to an overall plant modernization program, rather than be tackled as a separate problem. In addition, the bulk of the plant's water pollution is confined to the Dîmbovnic, a minor tributary of the Arges River that is not used for water supply or irrigation.

- The Dacia and Aro car factories have problems treating their wastewater, but do not require foreign funds or foreign technical assistance to resolve them. The two firms have the technology necessary to do so on their own.

The remaining three projects (serving Pitesti, Cîmpulung, and Curtea de Arges) are considered to be high-priority projects, suitable for further study and possible financing by international donors. All three municipalities contain significant industries that affect stream quality; wastewater from all three can affect the 2.1 million people served by the Bucharest water supply system, and all three discharge wastewater quantities that are large in comparison with the streamflows available for dilution and assimilation. Nitrates and phosphates from these three sources are causing eutrophication in the Arges, upstream from the Pitesti and Bucharest water supply intakes. As a result, the consensus of the WASH team and of ministry officials consulted is that the projects for the three municipalities should, pending further investigation, be considered as a single investment package, with no relative ranking of the three.

5.3 Projects for Prefeasibility Study

The WASH team concludes that the prefeasibility studies for the Arges basin should encompass the wastewater management needs of the three municipalities of Pitesti, Cîmpulung, and Curtea de Arges. The prefeasibility studies for each are presented in the following three chapters (6, 7, and 8 respectively) of this report. By providing more detailed information on the three systems, it is intended that a single financing package will address all three municipalities, rather than concentrate arbitrarily on a single one.

Before final design and construction can be undertaken, a more detailed feasibility study may be required. Draft terms of reference for the feasibility study are available from the WASH Operations Center.

5.4 Additional Program Elements

Other potential construction projects and technical assistance projects required in the Arges basin include the following:

- Rural water supply: Approximately 1 million people in the Arges basin are served by shallow wells in the phreatic aquifer, which is highly polluted by nitrates and phosphates. Small rural water supply systems should be developed, supplied from deeper, confined aquifers (60 m to 100 m belowground).

- River basin water-quality master plan: Gaining the financial commitment of the populace served, and of potential donors, will require resolving some of the technical, economic, financial, and organizational issues discussed in Chapter 5. It will also require the development of a politically acceptable method of waste load allocation, whether for phosphates or for other pollutants, and of a prioritized or staged implementation plan for constructing facilities. For these reasons, the team proposes that the Arges River basin water authority undertake the development of a master plan soon after the authority is established under Romania's new water law.

- Additional prefeasibility studies: All of the potential projects identified in this study are worth carrying out, given sufficient funds and suitable levels and types of technical assistance.

- Arpechim wastewater facilities plan: Within the next six months, USAID will finish its study of the energy sector (including Arpechim and other refineries), which will prioritize the relative economic efficiencies and markets for petrochemicals over an area stretching from Vienna to the Black Sea. Depending on the results of this study, and government programs to privatize, abandon, or expand industrial facilities, it may be decided to retain and improve the Arpechim petrochemical facilities. In that case, a detailed investigation of Arpechim's treatment requirements will be needed.

- Heavy-metals recovery plant: The Aro and Dacia car plants are having trouble disposing of sludge containing heavy metals. It may prove possible for the sludge to be processed and the heavy metals recovered and recycled economically using advanced technology. The cost of the recovery plant could be funded under a grant to foster the introduction of modern industrial treatment technology.

- Studies on solid wastes and hazardous wastes: All of the municipal officials interviewed mentioned solid wastes and hazardous wastes as a major problem area. Many existing dump sites sit on riverbanks or within the flood plains of rivers. Identifying suitable sites for sanitary landfills, and providing equipment for hauling, processing, and disposing of solid and hazardous wastes are needed. In the more distant future, remediation of hazardous-waste dump sites may be needed.

- Institutional development: Romania's municipalities have been given responsibility for solving wastewater problems, but they lack experience and exposure to the methods of municipal finance, organization, and management that have proved successful in other democratic free-market countries.

- DEMDESS assistance: The Danube Emissions Management Decision Support System (DEMDESS) software and database capabilities developed by WASH should be supported, so that Romania can continue to cooperate effectively with other Danubian countries. Assistance would include adding user-friendly elements to the software for its use by decision-makers and training of users both at the ministry and the Arges environmental inspectorate in Pitesti.

- Environmental management training and assistance: Under Romania's new environmental and water laws, decentralization of responsibilities to the local level will occur, including a new, strengthened Arges River basin authority and a new environmental inspectorate that will have responsibility for all media (water, land, and air) and for developing and reviewing environmental impact statements. Assistance should be provided to define appropriate national and river-basin organizational and managerial responsibilities and roles; activities and procedures; staff training and personnel qualifications; and laboratory equipment, transportation, and communications requirements.

Additional details on these potential program elements are available from the WASH Operations Center.

Chapter 6

PREFEASIBILITY STUDY—PITESTI

6.1 General

The objectives of the wastewater prefeasibility study for Pitesti were as follows:

- to identify the likely limits of the service area and the projected growth in population and wastewater flows through the year 2010;
- to develop a strategic plan for prioritized or staged rehabilitation and development of wastewater facilities, over the time periods of 1993-2000 and 2000-10;
- to estimate the costs of associated facilities, including those for municipal wastewater collection, conveyance, and treatment, and to define the requirements for improved industrial pretreatment facilities; and
- to examine the financial and institutional considerations in implementing the strategic plan.

These topics are considered below.

6.2 Service Area and Projected Flows

Pitesti's existing sewerage system is shown in Figure 7, and a map of the existing wastewater treatment plant is depicted in Figure 8. The city has developed in a strip along the west bank of the Arges River and is surrounded by relatively flat agricultural land and foothills. Industries are located primarily at the northern end of the city, while the Arpechim petrochemical complex and several other industries are at the southern end in the vicinity of the municipal wastewater treatment plant. Two shallow lakes, Gavani and Pitesti, have been built on the Arges River along the edge of Pitesti. Two industries on the east bank, a winery and an electric motor plant, are also served by the municipal treatment plant.

For many years Pitesti has been the industrial center within the upper Arges basin and has grown by drawing its population from nearby villages. Colibasi and the Dacia car factory are about 15 km from Pitesti on the Doamnei River and are considered locally to be within the suburbs of Pitesti. Pitesti's growth has been limited on one side by the river, but otherwise is unimpeded by the region's flat topography.

The WASH team initially considered including Colibasi and the Dacia car factory within the Pitesti wastewater service area, in order to bring under control phosphate emissions from these three sources in a single project but this idea was abandoned for three reasons:

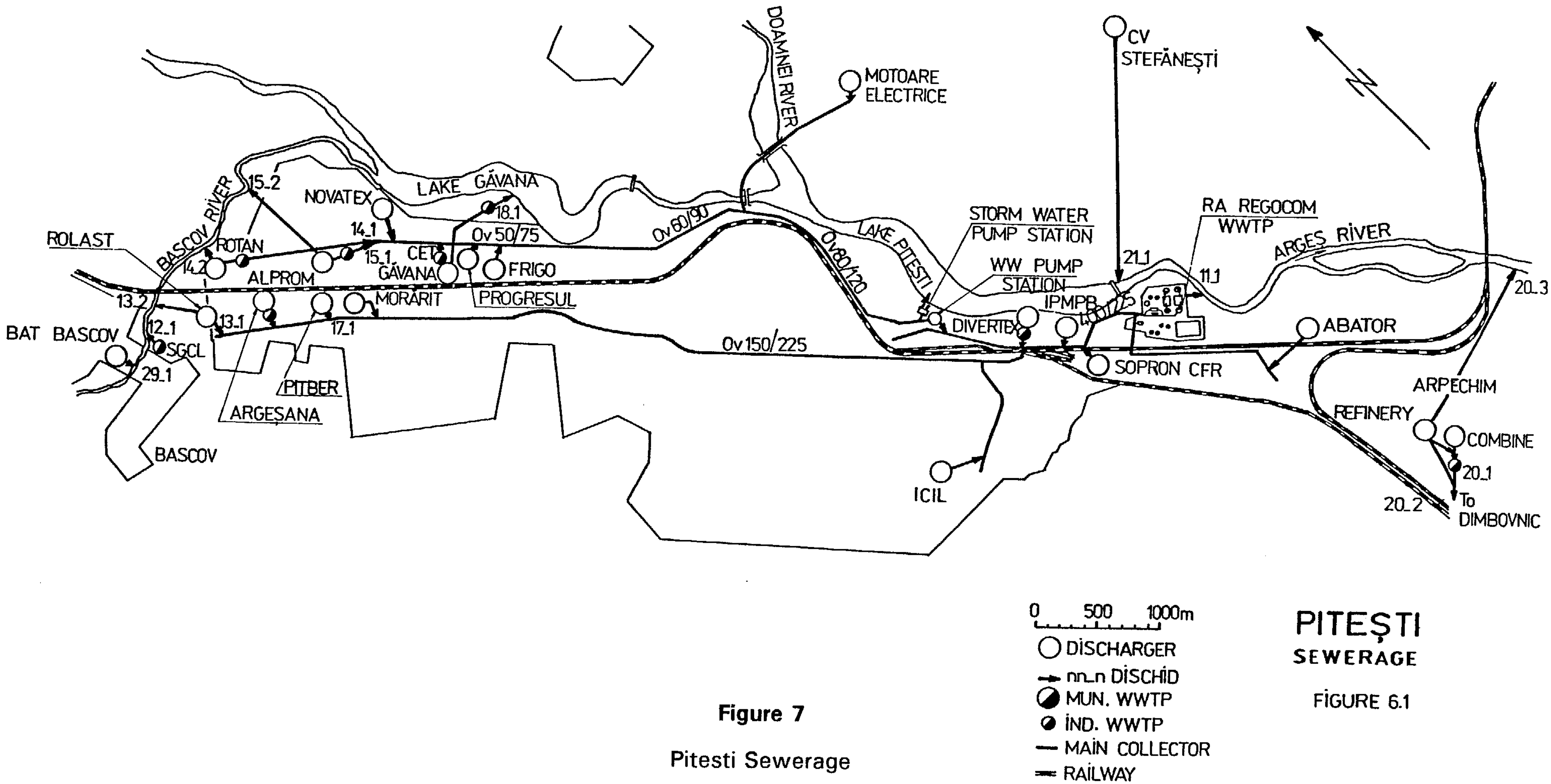

Figure 7

Pitesti Sewerage

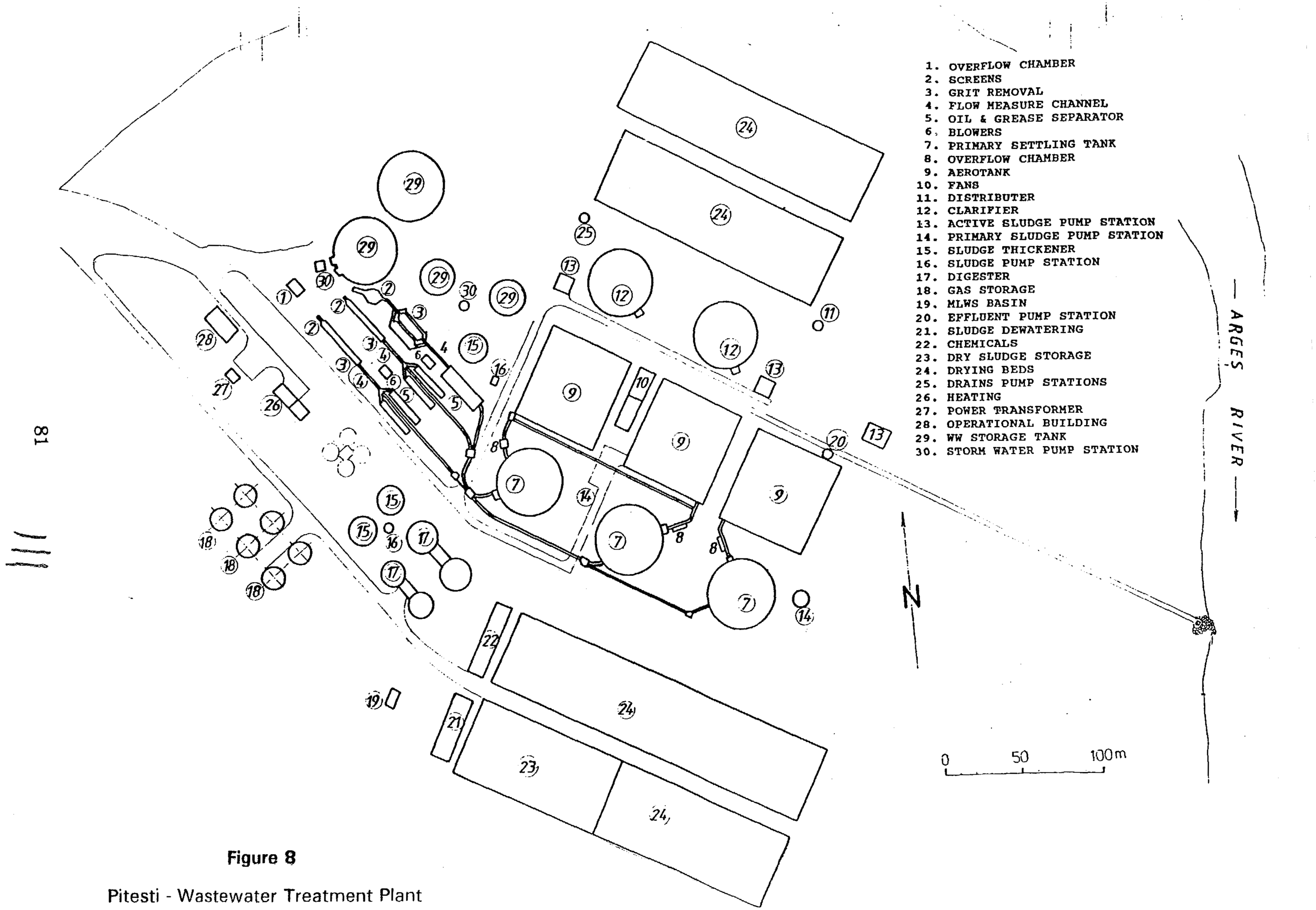

Figure 8

Pitesti - Wastewater Treatment Plant

- Any economic advantage from economy of scale in wastewater treatment facilities is marginal at best;

- The Dacia car factory might reduce its vigilance over pretreatment operations if the automaker discharged into a remote municipal plant. Additionally, the nature of the factory's wastes could cause catastrophic upsets in the biological treatment process in Pitesti's municipal plant.

- Municipal authorities in Pitesti are likely to be hesitant about the idea of accepting the wastewater problems of another municipality. In the distant future, the formation of a regional, semi-autonomous wastewater authority might relieve this reluctance, but a regional treatment plant does not appear to be a viable concept at present.

The projected wastewater flows to Pitesti's municipal wastewater treatment plant have been estimated from three sources of information: an initial design report in 1976 from the studies and Design Institute for Public Works (PROED) that contains flow projections to the year 2000; a questionnaire filled out by municipal officials in 1987 outlining Pitesti's water and wastewater services; and the DEMDESS data for 1992, provided by ICIM. These sources were supplemented by data provided by the Pitesti environmental inspectorate. Thus, the team's projection of wastewater flows is based on historical trends of increases in industrial, per capita domestic, and infiltration flows.

The 1976 PROED design report gave a projection that agrees with actual flows in 1987. The 1992 flow data also agree with the design report, except that industrial flows have declined in the last three years. For purposes of this study, the WASH team projected populations and domestic flows to match the growth rates in the design report up to the year 2000: 3.2 percent per year population growth, and modest increases in per capita flows and percentage served. The team also assumed that industry will recover by the year 2000 and resume the trend in wastewater flows that occurred from 1976-87. For the period 2000-10, the team assumed a declining growth rate in population, averaging 2.6 percent per year, and a continuation of the growth in industrial wastewater flows. Infiltration has been estimated very roughly, in the range of 20 to 25 percent of total flow.

Successful programs to reduce wastewater flows obviously would reduce the required treatment capacities and costs estimated herein. Such programs would include efforts to do the following:

- reduce industrial flows by minimizing waste in basic industrial production processes;

- reduce domestic flows via improved metering, higher tariffs, reduced waste from leaking plumbing fixtures, and, if practical, abandonment of the wasteful public hot water system, which is unmetered; and

- reduce infiltration by rehabilitating sewers.

The team's projected wastewater flows are shown in Table 37; they indicate an increase from 156,000 cmd at present to 300,000 cmd in the year 2010.

Table 37

Projected Wastewater Flows for Pitesti

Year	Population		Estimated Flow (cmd)			
	Total	Served	Domestic	Industrial	Infiltration	Total
1993	201,500	191,500	86,000	40,000	30,000	156,000
2000	245,000	233,000	117,000	87,000	50,000	254,000
2010	285,000	271,000	140,000	110,000	50,000	300,000

6.3 Development of a Strategic Plan

6.3.1 Conveyance Facilities

Pitesti is served by a combined-sewer system, carrying both storm water and wastewater to the treatment plant. At the entrance to the plant, the total capacity of a large ovoid sewer (4 m high by 2.55 m wide) carrying much of the influent is reported to be 12 m^3/sec, or more than 1 million cmd. This is much in excess of estimated peak wastewater flows, and thus there is no readily apparent need to expand the major collectors and interceptors within the service area. Collection systems of smaller secondary sewers, however, will require extensions to serve new areas as the population grows.

Lake Pitesti has a normal water level that is 5 m above ground level along the major riverside interceptors. As a result, infiltration of groundwater into the sewers and interceptors is reported to be large. The new ovoid interceptor is a replacement for a brick-lined sewer built in 1905, which collapsed because its concrete bottom deteriorated. Structural deterioration of concrete from sulfides (generated by sewage during warm periods) may be occurring in other older sewers.

As a result of the above, proposed improvements in conveyance facilities consist of two items: extensions to the collection system to serve additional people, and remote-camera inspection followed by rehabilitation of a portion of the sewerage system.

6.3.2 Municipal Treatment Facilities

The municipal wastewater treatment plant in Pitesti is a secondary treatment plant using activated sludge. Much of its equipment is old and poorly maintained, and the plant's preliminary treatment train is undersized. Additionally, the plant's laboratory capability is inadequate for plant operation and industrial pretreatment monitoring, and its operations and maintenance (O&M) systems are insufficient to maintain reliable and efficient treatment.

Inadequate treatment of the town's wastewater can result in unacceptable loadings of BOD, solids, nutrients, and heavy metals to the Arges River and downstream reservoirs, thereby threatening the water supply of Bucharest. Several changes can be identified for the Pitesti WWTP to protect the river under existing and future wastewater flows.

Immediate needs

The laboratory at the WWTP must be able to perform the analyses required for effective operation of the treatment process. In addition, analytical capability to detect nitrogen compounds, phosphorus, and heavy metals should be available so that the performance of the industrial pretreatment facilities can be monitored. Some of these capabilities, such as metals analysis, may be more efficient if made available at the inspectorate level.

Operator training is needed to ensure the establishment of effective O&M procedures. This training should include methods for routine process operation and monitoring; procedures for handling upsets and unusual conditions; preventive maintenance; worker safety; and record keeping. It is assumed that the secondary treatment facilities proposed below can be operated to minimize the phosphorus content of the effluent to the river by maximizing the phosphorus in the sludge. In addition, an industrial waste minimization program will be needed to eliminate large quantities of phosphorus and nitrogen compounds of industrial origin.

Because of the poor condition of the plant's equipment, a comprehensive plant audit is needed to identify exactly what components should be replaced or rehabilitated. However, it can be concluded from an initial plant inspection and conversations with operators and engineers that a large portion of the mechanical and electrical equipment must be replaced for the process to operate efficiently.

The preliminary treatment train has a capacity of 127,000 cmd. Therefore, an additional 63,000 cmd is needed to match the total plant design capacity of 190,000 cmd.

Phase I needs for the year 2000

By the year 2000, Pitesti's wastewater flow is predicted to increase by 98,000 cmd to 254,000 cmd. When the rehabilitation of the existing plant is complete (as described above), it should have a total capacity of 190,000 cmd. Therefore, it will be necessary to add primary treatment, secondary treatment, sludge digestion, and sludge dewatering capacity for an additional 64,000 cmd to satisfy Phase I conditions.

A combination of industrial waste minimization and careful plant operation should be employed to reduce phosphorus concentrations in the effluent. Nitrogen compounds from industrial sources can be minimized; however, it may also be necessary to include a nitrification and denitrification process at the municipal plant.

Phase II needs for the year 2010

It is projected that the year 2010 will bring the need for an additional 46,000 cmd of wastewater treatment capacity for a total capacity of 300,000 cmd. The added flow will require additional primary treatment, secondary treatment, nitrification, denitrification, sludge digestion, and sludge dewatering capacity.

6.3.3 Industrial Pretreatment Facilities

Sixteen major industries emit wastewater to the Pitesti municipal wastewater treatment plant. These industries account for a combined flow of 21,000 cmd, a BOD loading of 5,500 kg/day, total suspended solids (TSS) 10,900 kg/day, 33 kg/day of nitrate, 591 kg/day of ammonia, and 41 kg/day of phosphate (see Appendix B, Tables B5 and B6). The phosphate loading from these industries is significant when compared with the phosphate in the effluent from the municipal plant (51.5 kg/day). If the municipal plant removes an estimated 20 percent of the influent phosphate, the total phosphate loading to the municipal plant is about 64 kg/day (51.5 divided by 0.8). This assumption leads to the conclusion that 64 percent (41 kg/day out of 64 kg/day) of the phosphate loading to the Pitesti municipal wastewater treatment plant is from industrial sources. The majority of the industrial phosphorus comes from three dischargers: the textile manufacturer Divertex, the brewery Pitbere and the tannery Rotan.

The wastewater flow from the industries discharging to the Pitesti municipal system is currently only one-third of the design flow allocated to industry in the 1976 PROED design report. Therefore, a return of the economy to maximum production could result in a threefold increase in industrial wastewater discharged to the municipal plant. Thus the major industries would account for about 63,000 cmd (or three times their current flow of 21,000 cmd) of the 87,000 cmd allocated to industry in the industrial flow projections given in Table 37.

The following are details on the changes possible at each industry to reduce the contaminant load on the Pitesti municipal plant. For a summary of the data for the six most significant industrial polluters, see Table 38.

Alprom (formerly CPL [DEMDESS No. 15-1])

This plant produces wood products, including pressed fiberboard. The wastewater from its process consists of two streams—a concentrated stream from the first stage of the board-making process, and a diluted stream from the dewatering stage of the process. The more concentrated waste stream is processed into animal feed while the more diluted stream is discharged to the municipal sewer with minimal mechanical and chemical pretreatment. The diluted wastewater stream is not processed into animal feed because, according to industry personnel, it is not economical to do so; however, processing the diluted stream onto animal feed should be reevaluated as an alternative to conventional wastewater treatment.

Table 38

Industrial Pretreatment Requirements for Pitesti

Industry Name	Description	Flow Rate	Major Contaminants	Needs
Alprom	Wood products	4,320 cmd	BOD, 3,500 kg/day; nitrate, 15 kg/day; ammonia, 95 kg/day;	- Waste minimization - BOD removal facilities - Nitrogen removal facilities
Rotan	Leather products	1,397 cmd	BOD, 485 kg/day; ammonia, 201 kg/day; phosphate, 6 kg/day;	- Waste minimization - BOD removal facilities - Nitrogen removal facilities
Novatex	Textiles	4,320 cmd	Ammonia, 212 kg/day	- Waste minimization - Nitrogen removal facilities
Argesana	Textiles	3,456 cmd	COD, 4,285 kg/day	- Waste minimization
Divertex	Textiles	2,592 cmd	Phosphate, 12 kg/day	- Waste minimization - Phosphorous removal facilities
Pitbere	Beer	259 cmd	Phosphate, 18 kg/day	- Waste minimization - Phosphorous removal facilities

The plant's emission to the municipal system totals 4,320 cmd and contains a large amount of BOD (800 mg/L and 3,500 kg/day), nitrate (3.4 mg/L and 14.7 kg/day), and ammonia (22.1 mg/L and 95.3 kg/day). The ammonia content of the waste stream is the most significant because the municipal system is not equipped to remove nitrogen compounds. The 3,500 kg/day BOD loading is 13 percent of the estimated 27,000 kg/day total BOD loading to the Pitesti municipal plant.

Discrepancies exist between the data obtained from the local inspectorate, ICIM, and industry representatives; therefore, additional analyses are warranted. In addition, it is unclear whether the data for nitrogen and phosphorous compounds are reported on a consistent basis—for example, as NO_3^- or as N, as PO_4^{-3} or as P. Additionally, data are lacking for the analysis of organic nitrogen; therefore, it is not possible to calculate total nitrogen loading to the plant.

Possible pretreatment processes include biological treatment to remove BOD, biological nitrification and denitrification, ammonia stripping, and gravity settling to remove suspended solids. Due to the unconventional characteristics of this wastewater, pilot testing of the biological treatment processes is justified prior to full-scale implementation.

Rotan (formerly Tananti [DEMDESS No. 14-1])

This leather processing facility has high BOD, TSS, nitrogen compounds, and phosphorus in its effluent. (Available data are inconsistent and must be supplemented.) The facility currently uses mechanical and chemical treatment for its wastewater (1,397 cmd). The phosphorus and ammonia content of the wastewater from this plant apparently account for a significant portion of the total loading on Pitesti's municipal system. Rotan discharges 6.1 kg/day of phosphates, which may account for 10 percent of the total loading to the municipality, assuming a total loading of 64 kg/day, as noted earlier. The facility contributes 201.2 kg/day of ammonia, or 5 percent of the total municipal influent ammonia loading of 3,456 kg/day. Because Rotan does not do chromate tanning, it does not emit chromium in its effluent.

Pretreatment technologies for this industry that may be feasible include air stripping of ammonia, biological nitrification and denitrification, biological phosphorus removal, and chemical precipitation of phosphorus. Further investigation and pilot testing of pretreatment options is necessary. Minimization of phosphorus-containing wastes should also be investigated.

Novatex (formerly Text. Gavana)

Novatex, a textile manufacturer, emits wastewater with a high ammonia loading (49 mg/L or 212 kg/day), and contains a large proportion of nonbiodegradable COD (BOD = 75 mg/L and COD-Cr = 1,600). No pretreatment is currently employed here. Physical (air stripping) or biological removal of ammonia (with proper pilot testing) is a pretreatment option for the 4,320 cmd wastewater flow rate.

Argesana

Argesana produces textiles and a wastewater flow rate of 3,456 cmd. Its wastewater contains nonbiodegradable COD (BOD = 145 mg/L and COD-Cr = 1,240 [COD-Cr is chemical oxygen demand measured using a chromate oxidant]). The ammonia concentration in the facility's emission is 14 mg/L; however, loading is minor. Both of these contaminants come from dyeing operations. Waste minimization measures may be effective here. The factory currently has facilities for mechanical and biological treatment. However, the biological portion of the treatment process is unused because of problems with maintaining a biomass in the treatment system.

Divertex

Divertex is also a textile manufacturer; however, its wastewater has significantly different characteristics from those of Argesana and Novatex. The plant's phosphate concentration is 4.8 mg/L with a flow rate of 2,592 cmd. The total loading of phosphate therefore is 12.4 kg/day, 19 percent of the total municipal phosphate loading assumed above. The plant currently employs mechanical and chemical treatment (a field inspection has not been made of these facilities). Chemical or biological removal of phosphorus may be possible; however, all processes must be pilot tested.

Pitbere (formerly Fabrica de Bere [DEMDESS No. 17-1])

Conflicting flow rates have been reported for this brewery; however, it appears that its phosphate loading to the municipal system is large. No data were available regarding soluable BODs. This plant should be investigated to confirm its effluent quality and quantity, determine feasible pretreatment technologies, and determine whether waste minimization is possible.

Other industries

The following industries do not contribute a significant pollutant loading to Pitesti's municipal treatment plant.

- Rolast, formerly CATC (CATC, DEMDESS No. 13-1)—rubber products.
- Cet Gavana—municipal heat and electric power plant.
- Morarit, formerly Panificatie—flour mill and bakery.
- Frigorifer—frozen storage facility.
- Progresul, formerly FPAPM—leather products.
- Motare Elect., formerly YME—electric motors. No major pollution is apparent in this facility's wastewater; nevertheless, it should be monitored for heavy metals. If necessary, a sludge management program should also be implemented here.
- Icil—dairy products. No flow rate data were available on this plant's wastewater. BOD concentration was moderate at 130 mg/L.
- Ipmbp—fabricates components for bridges. It generates a significant flow to the municipal plant, but little contamination.
- Abator—slaughterhouse.
- Sopron—railway shelter.

General

Additional data needed about industrial dischargers for future feasibility or design studies include the following:

- An analysis of the organic nitrogen content of all industrial emissions is needed to calculate the total nitrogen loading to the Pitesti municipal treatment plant. No such data have been located; therefore, it will be necessary to perform several analyses on each emission to obtain an accurate representation of the waste stream.

- An examination of the industries most likely to have metals and synthetic organics in their effluent to determine if they do indeed emit significant concentrations.

- Emission characteristics must be related to the production process of each discharger. An accurate assessment must be made of how the emission quantity and quality would change with increased or decreased production. In addition, expected changes in production processes should also be evaluated for effects on emissions.

- Each industry should be evaluated to identify additional waste minimization opportunities.

- Institutional and facilities requirements for the implementation of spill prevention and control programs should be determined for each industry. These programs are intended to reduce the probability of spills to the municipal WWTP or directly to the river.

- Chemical analysis capability is required to monitor industrial pretreatment operations. This capability can be made available through the inspectorate, the municipality, or the industries.

- Pilot plant testing of wastewater technologies is needed to verify design parameters on the industries noted above.

6.4 Estimated Costs

The strategic plan presented in Section 6.3 is summarized with pertinent estimated capital costs in Table 39.

The estimated capital costs for components of the wastewater treatment plant were developed by adapting cost functions for similar facilities presented in publications published by the United States Environmental Protection Agency (EPA). The cost functions were updated to 1993 conditions by applying the *Engineering News Record* construction cost index of 5,200 to obtain an equivalent cost in the United States. This cost was converted to current Romanian market costs by applying factors to the labor, materials, and equipment components of the facilities costs, and a 20 percent contingency was added to obtain the total estimated capital costs in Romania.

Noncapital project costs for wastewater treatment plant staff and laboratory upgrading, and those for sewer system testing and repair were estimated.

O&M costs, shown in Table 40, were estimated by adjusting the components given by EPA cost functions for similar activities. The component costs were converted to equivalent units or quantities of man-hours, kwh of electricity, and materials. Applicable current Romanian market costs were applied to obtain the O&M values.

Table 39

Pitesti Municipal Wastewater Facilities—Summary of Strategic Plan

Investment Description	When Needed	Flow or Condition Covered	Cost[a]		Comments
			Million Lei	Thousand Dollars[b]	
A) <u>Immediate</u>					
1) Improve existing sewer system.	Immediately	Existing flow = 156,000 cmd	60	100	Covers inspection of, smoke tests of, and repairs to the parts of the existing sewers that are in very poor condition.
2) Optimize O&M operations at WWTP. Improve WWTP laboratory.	Immediately	Existing flow = 156,000 cmd	90	150	Optimize plant O&M to improve phosphorous removal. Improve laboratory capabilities and municipal enterprise operations to detect and control industrial sources of phosphorous and nitrogen.
3) Rehabilitate mechanical and electrical equipment at existing WWTP.	Immediately	Existing flow = 156,000 cmd	1,800	3,000	Much of the equipment at the existing plant is old and poorly maintained. A large portion of the mechanical and electrical equipment must be replaced for the process to operate efficiently.
4) Expand preliminary treatment	Immediately	Existing flow = 156,000 cmd	120	200	The existing preliminary treatment capacity is only 127,000 cmd. Add 63,000 cmd preliminary treatment capacity to match total plant capacity of 190,000 cmd.
B) <u>Phase I</u>					
5) Sewer additions.	Year 2000	Existing flow + 98,000 cmd total = 254,000 cmd	270	450	Add new sewers to serve an additional 42,000 persons.
6) Primary, secondary, and sludge digestion additions.	Year 2000	Existing flow + 98,000 cmd total = 254,000 cmd	2,880	4,800	Existing facilities should have a 190,000 cmd capacity when rehabilitated (item 3 above). Additional 64,000 cmd capacity includes primary treatment, secondary treatment, and sludge digestion added to existing WWTP.

(continued)

Table 39 (continued)

Investment Description	When Needed	Flow or Condition Covered	Cost[a]		Comments
			Million Lei	Thousand Dollars[b]	
7) Nitrification and denitrification and filter press additions.	Year 2000	Existing flow + 98,000 cmd total = 254,000 cmd	7,200	12,000	Add nitrification, denitrification, and sludge filter press capacity for the full Phase I flow (254,000 cmd).
C) Phase II					
8) Primary, secondary, nitrification, denitrification, sludge digestion, and filter press additions.	Year 2010	Phase I + 46,000 cmd total = 300,000 cmd	3,700	6,150	Additional 46,000 cmd capacity includes primary treatment, secondary treatment, nitrification, denitrification, sludge digestion, and sludge filter press.
9) Sewer additions.	Year 2010	Phase I + 46,000 cmd total = 300,000 cmd	200	350	Add new sewers to serve an additional 38,000 persons.
Summary					
A) Immediate Costs: Items 1 - 4	Immediately	Existing flow = 156,000 cmd	2,070	3,450	
B) Phase I Costs: Items 5 - 7	Year 2000	254,000 cmd	10,350	17,250	
C) Phase II Costs: Items 8 and 9	Year 2010	300,000 cmd	3,900	6,500	
		TOTAL	16,320	27,200	

[a] Costs represent 1993 Romanian market costs and include 20 percent for contingencies.
[b] Exchange rate of 600 lei/$US 1.

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Table 40

Estimated O&M Costs for Pitesti

Condition	Additional Annual O&M Costs (Million Lei/Year)	Total Cumulative Annual O&M Costs (Million Lei/Year)
Existing Conditions	306	306
Immediate Improvements	30	339
Phase I Improvements	513	852
Phase II Improvements	140	992

6.5 Financial Considerations

Financing for all of the capital cost requirements for the Pitesti strategic plan is based upon borrowing the total amount, through loans at a 12-percent interest rate and 20-year repayment term. The cost recovery for the loan payments plus the O&M requirements are assumed to be provided through tariff charges. Thus the Pitesti strategic plan is assumed to be financially self-sufficient, with no direct government subsidy.

The required annual costs, average tariffs, and monthly cost for a typical household to finance the strategic plan are summarized in Table 41. The table illustrates the cost and tariff requirements for the "online conditions" of all facilities and improvements, and thus the most expensive case in terms of those system customers who will pay these costs.

Table 41 indicates that the household costs are relatively high in terms of the percentage of income for all but the immediate improvements. However, the costs shown in the table are reasonable considering the following key assumptions:

- All costs are covered by the tariffs to produce a break-even situation; the loan conditions are for future economic conditions. National policy may allow, as is the case in many wastewater programs throughout the world, for a portion of the capital cost to be provided as a government grant. Furthermore, total financing through loans may be only one of several mechanisms available for investments (see discussion in Chapter 4).

- Tariffs are computed assuming no cross-subsidies from industrial users. If the analysis included industrial tariffs at one-half the current level (i.e., 3.7 times the domestic tariff levels), the tariffs shown in Table 41 would be reduced by 50 to 60 percent.

- Household charges are computed assuming that they are assessed by billing individual households. The Pitesti service area contains approximately 3,600 water meters. This indicates the urbanized character of the municipality, with most people residing in high-rise apartment houses, with water supply service, and thus wastewater collection, being provided on an apartment block or areal basis. In such systems, it is common for management to assess individual household charges, recognizing the varying use among householders and their ability to pay.

- The ability-to-pay comparison in the table is based on the January 1993 national average wage level in urban areas of 27,763 lei per month. Chapter 4 indicates that about 45 percent of Romania's workers are at wage levels above the average.

- The monthly household charges in Table 41 are shown for cost conditions representing the total investments for the design horizons for Phases I and II (years 2000 and 2010, respectively). The actual costs required may be less, as the capital costs will be spread over several years.

- The costs used to compute the tariffs do not consider any reductions in operating costs gained through the immediate improvements. Such investments in Pitesti's existing wastewater collection system and treatment plant, combined with those for optimizing treatment plant O&M, should cause the base O&M costs to decrease.

Table 41

Financial Impacts—Pitesti

	Estimated Capital Cost of Facilities Added		Additional Annual O&M Cost[c]	Total Cumulative Annual Cost	Domestic Tariff[d]	Average Monthly Cost per Household[e]	Percentage of Income[f,g]	Percentage of Income of Bottom Third[f,g]
	Total[a]	Annual[b]						
	Million Lei	Million Lei	Million Lei	Million Lei	Lei/m^3	Lei	%	%
Existing Conditions	--	--	306	306	5.4	363	1.3	1.6
Immediate Improvements	2,070	277	30	613	11.0	743	2.7	3.5
Phase I Improvements	10,350	1,386	513	2,512	27.0	2,050	7.4	8.5
Phase II Improvements	3,900	522	140	3,174	29.0	2,185	7.9	9.9

(a) From Table 39.
(b) Average annual payment to repay loan with an interest rate of 12 percent and a 20 year term.
(c) From Table 40.
(d) The tariffs are computed assuming no cross-subsidies from industrial users.
(e) Equivalent household tariff charge assuming each household was charged as an individual customer.
(f) Percent of average national wage level: January 1993 = 27,763 lei.
(g) From ability-to-pay discussion in Chapter 4.

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Chapter 7

PREFEASIBILITY STUDY—CÎMPULUNG

7.1 General

The objectives of the wastewater prefeasibility study for Cîmpulung were as follows:

- to identify the likely limits of the service area and the projected growth in population and wastewater flows through the year 2010;
- to develop a strategic plan for prioritized or staged rehabilitation and development of wastewater facilities, over the time periods of 1993-2000 and 2000-10;
- to estimate the costs of associated facilities, including those for municipal wastewater collection, conveyance, and treatment, as well as industrial pretreatment facilities; and
- to examine the financial and institutional considerations in implementing the strategic plan.

These topics are considered below.

7.2 Service Area and Projected Flows

Cimpulung's existing sewerage system is shown in Figure 9, and a map of the municipality's existing wastewater treatment plant is depicted in Figure 10. Cîmpulung is located in a narrow, steep-sided river valley and occupies both sides of the Tîrgului River. The town's two largest industries, the Aro car factory and the Grulen synthetic-fibers plant, are located in its northern end, on the west bank. Three smaller industries are dispersed along the east bank. The cement plant in Cîmpulung is located in an adjacent river valley to the east and is not within the town itself.

Cîmpulung was the capital of Romania in medieval times and contains many well-preserved historical buildings. It features a beautiful setting and has obvious potential for tourism, but the town is not expected to grow into a major city because of the topographic constraints of the valley. The WASH team assumed that much of Cimpulung's future population and industry can be accommodated within the existing service area of the treatment plant, or on adjacent land that can be served by minor extensions of secondary sewers.

Projected wastewater flows to Cimpulung's municipal wastewater treatment plant were estimated from three sources of information: a PROED design report in 1976 containing flow projections to the year 1990; a questionnaire filled out by municipality officials in 1987 outlining the town's water and wastewater services; and DEMDESS data for 1992, provided by ICIM. These sources were supplemented by data provided by the environmental inspectorate in Pitesti.

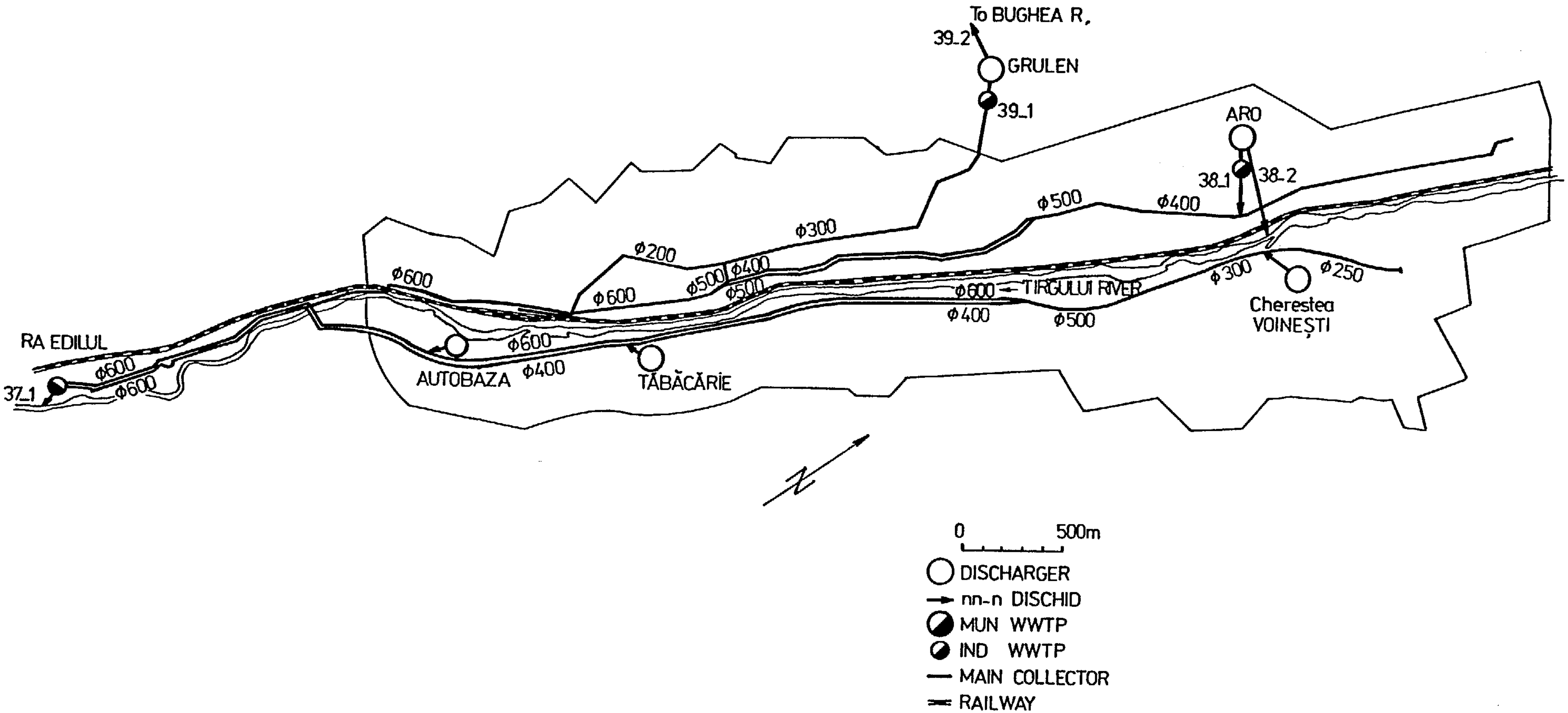

Figure 9

Cîmpulung Sewerage

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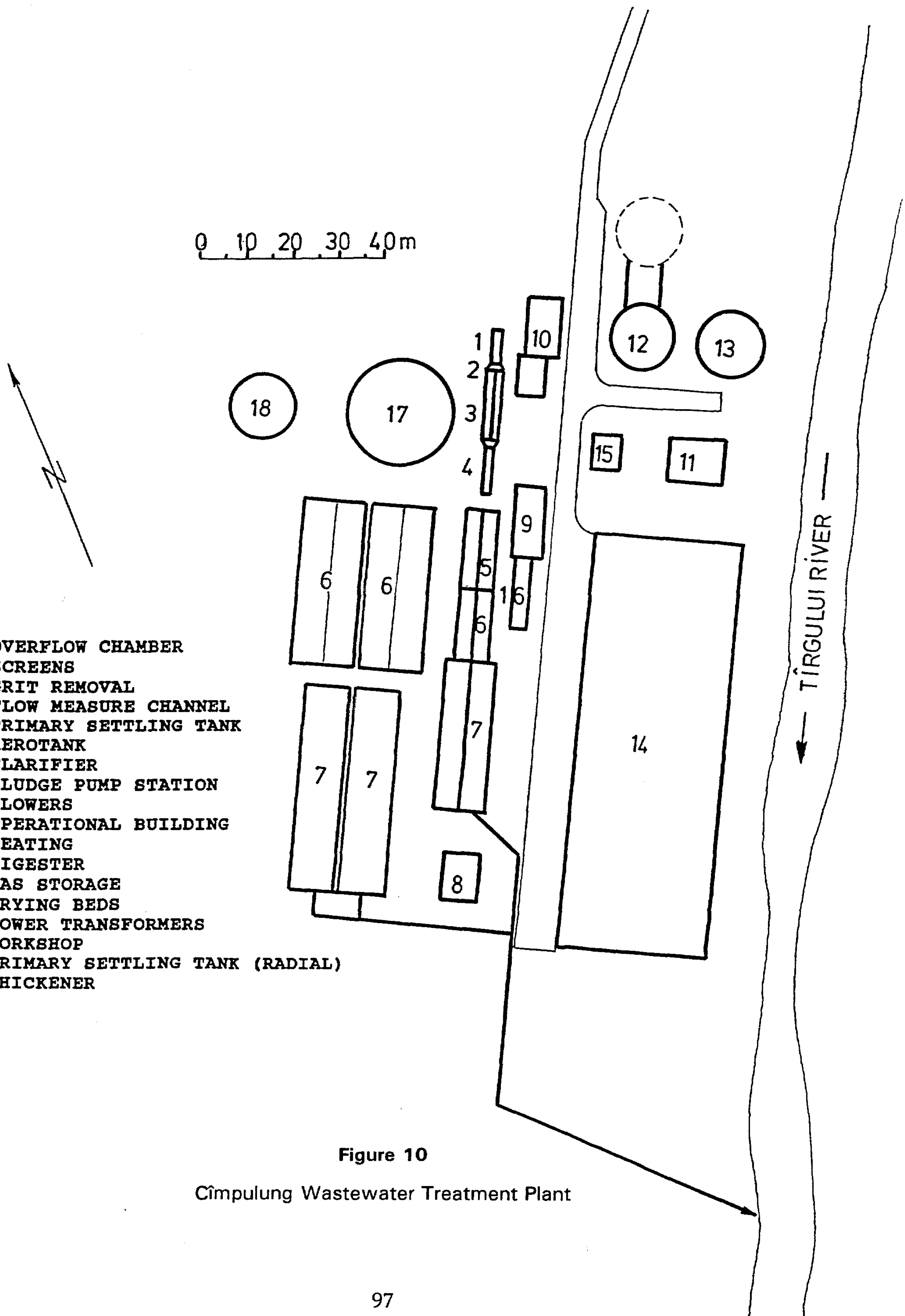

1. OVERFLOW CHAMBER
2. SCREENS
3. GRIT REMOVAL
4. FLOW MEASURE CHANNEL
5. PRIMARY SETTLING TANK
6. AEROTANK
7. CLARIFIER
8. SLUDGE PUMP STATION
9. BLOWERS
10. OPERATIONAL BUILDING
11. HEATING
12. DIGESTER
13. GAS STORAGE
14. DRYING BEDS
15. POWER TRANSFORMERS
16. WORKSHOP
17. PRIMARY SETTLING TANK (RADIAL)
18. THICKENER

Figure 10

Cîmpulung Wastewater Treatment Plant

PROED's 1976 design report under-estimated the industrial flows, and over-estimated the domestic flows reported for 1987. In both sources of data, no estimates of infiltration to sewers are given. For purposes of this report, we have estimated the corresponding domestic and industrial flows currently, also without infiltration, and projected them forward from the known populations and flows in 1993.

The resulting projected wastewater flows are shown in Table 42 and indicate an increase from 22,000 cmd at present to 38,000 cmd in the year 2010. Since the existing nominal capacity of the wastewater treatment plant is 39,000 cmd, no attempt was made to refine the flow projection to include infiltration and to make corresponding adjustments in the domestic and industrial flows.

Table 42

Projected Wastewater Flows for Cîmpulung

Year	Population		Estimated Flow (cmd)			
	Total	Served	Domestic	Industrial	Infiltration	Total
1993	48,700	40,000	10,000	12,300	0	22,300
2000	54,900	46,700	14,000	14,000	0	28,000
2010	60,600	54,600	19,000	19,000	0	38,000

7.3 Development of a Strategic Plan

7.3.1 Conveyance Facilities

Cîmpulung is served by a separate sanitary sewer system, shown in Figure 9. Sewer capacities compared with projected peak flows were not computed, due to lack of detailed information on sewer slopes and friction factors. However, the diameters of the existing sewers appear sufficient for the projected flows.

Field studies and remote-camera inspection of sewers to identify sources of infiltration of groundwater are proposed. This is considered essential to identify needs for sewer rehabilitation to reduce flows and operating costs and to improve treatment efficiency at the treatment plant.

Existing sanitary sewers have a total length of 30 km and are concrete, 250 mm to 600 mm in diameter (except for one ovoid sewer, 1,200 mm high by 800 mm wide), and generally are 20 to 40 years old. The concrete sewers may have deteriorated from sewage sulfide attack during warm weather, and hence a cost allowance has been made for remote-camera inspection and rehabilitation for a portion of Cîmpulung's sewerage system. In addition, the collection system will require extensions to serve new areas as the town's population grows.

Thus, the proposed improvements in conveyance facilities consist of two items: extensions to the collection system to serve additional people, and remote-camera inspection followed by rehabilitation of a portion of the sewerage system.

7.3.2 Municipal Treatment Facilities

The municipal wastewater treatment plant in Cîmpulung is a secondary treatment plant using activated sludge. The existing secondary treatment facilities have an adequate design capacity for current flows, but poor plant operation results in low-quality effluent. Existing sludge digestion facilities need rehabilitating and are undersized for the current flow. The existing preliminary treatment facility is also undersized. The plant's laboratory capability is inadequate for plant operation and industrial pretreatment monitoring, and operations and maintenance (O&M) systems are insufficient to maintain reliable and efficient treatment. Inadequate treatment of the town's wastewater can result in unacceptable loadings of BOD, solids, nutrients, and heavy metals to the Tîrgului and Doamnei rivers, and to downstream reservoirs on the Arges, thus threatening the water supply of Bucharest. Several improvements can be identified for the Cîmpulung WWTP to protect the river for existing and future wastewater flows.

Immediate Needs

The laboratory at the WWTP must be able to perform the necessary analyses to operate the treatment process. In addition, analytical capability to detect nitrogen compounds, phosphorus, and heavy metals should be available so that the performance of the industrial pretreatment facilities can be monitored. Some of these capabilities, such as metals analysis, may be more efficient if made available at the inspectorate level.

Operator training is needed to ensure the establishment of effective O&M procedures. This training should include methods for routine process operation and monitoring; procedures for handling upsets and unusual conditions; preventive maintenance; worker safety; and record keeping. The existing secondary treatment facilities can be operated to minimize the phosphorus content of the effluent to the river by maximizing the phosphorus in the sludge. In addition, an industrial waste minimization program will be needed to eliminate large quantities of phosphorus and nitrogen compounds of industrial origin. Assuming these measures are implemented, it is possible that the assimilative capacity of the river is high enough that additional nutrient removal from this municipality is not needed to prevent eutrophication of downstream reservoirs.

As noted above, the mechanical and electrical equipment in the existing sludge digester needs rehabilitation. When operating properly, the digester will have a capacity adequate to serve one-third of the current flow. Therefore, additional digester capacity for two-thirds of the current flow is needed. Because incremental cost to increase the digester capacity to Phase II levels is small, it would be prudent to build the increased capacity immediately.

Existing preliminary treatment is adequate for only 13,000 cmd. Therefore, 9,300 cmd capacity is needed to treat existing flows.

Phase I Needs for the Year 2000

By the year 2000, Cîmpulung's wastewater flow is predicted to increase by 5,700 cmd to 28,000 cmd. The existing secondary treatment capacity should be adequate for the projected Phase I flow. However, the sludge thickener and dewatering capacity will need to be increased. As with the digester capacity, the incremental cost to increase the sludge capacity to Phase II levels is small; therefore, the increased size is recommended.

A combination of industrial waste minimization and careful plant operation should be sufficient to reduce phosphorus and nitrogen compound concentrations in the effluent. By careful operation, expensive nitrification and denitrification processes could be avoided for this plant, where the flow magnitude will remain small compared with the water supply flows in the Arges needed to supply Bucharest.

Phase II Needs for the Year 2010

It is assumed that the year 2010 will bring the need for an additional 10,000 cmd of wastewater treatment capacity for a total capacity of 38,000 cmd. The added flow will require only additional secondary treatment aeration capacity if sludge processing facilities are sized as described above.

7.3.3 Industrial Pretreatment Facilities

Five major industries emit wastewater to the Cîmpulung municipal wastewater treatment plant. These industries account for a combined flow of 12,000 cmd, a BOD loading of 932 kg/day, total suspended solids (TSS) of 4,271 kg/day, 8 kg/day of nitrate and 86 kg/day of ammonia. Phosphate data are unavailable. Details are provided in Appendix B, Tables B5 and B6.

The following are details on the changes possible at each industry to reduce the contaminant load on the Cîmpulung municipal plant. For a summary of the data for the three most significant industrial polluters, see Table 43.

Aro (DEMDESS No. 38-1)

The Aro factory manufactures four-wheel-drive vehicles. The wastewater of concern comes from its metal finishing operations. These operations include the use of cyanide, phosphorus, ammonia, chromium, cadmium, and nickel. There is also concern for the possibility of spills from these processes and from storage of spent plating solutions on-site.

Total flow for the facility is 8,640 cmd. Ammonia concentration in the effluent is moderate at 7.4 mg/L, but the high flow rate results in a large ammonia loading (64 kg/day) to the municipal plant. This is 74 percent of the municipal plant's total industrial ammonia loading.

A combination of waste minimization and improvement or replacement of Aro's pretreatment facilities would serve to lower its load of heavy metals, nitrogen, and phosphorus to Cîmpulung's municipal treatment plant. Facilities are used that perform conventional chromium reduction, cyanide destruction, and metals precipitation, but they need to be evaluated and upgraded. Phosphorous compounds can also be removed with such a system. Treatment to remove nitrogen compounds would probably be infeasible due to the relatively low concentration in Aro's effluent and the high flow rate. Additional laboratory equipment, including an atomic adsorption spectrophotometer, is needed to improve control of the automaker's wastewater pretreatment process. Plant personnel are evaluating a noncyanide zinc plating process to replace the use of cadmium.

The generation of metal-containing sludges from the conventional treatment processes requires an improved sludge management program, including minimization, dewatering, and investigation of recovery and recycling options. The plant currently generates 50 tons per year of sludge (at 30 percent dry solids). Some of this sludge is reclaimed in Baia Mare, but capacity of the reclaimer is limited.

Grulen (formerly CFS [DEMDESS No. 39-1])

This plant manufactures polyester fibers. It employs mechanical, biological, and chemical wastewater treatment processes. In general its treatment is effective, resulting in a minimal loading to the municipal treatment plant of all contaminants except ammonia (13 kg/day, or 16 percent of the industrial ammonia load). Waste minimization and pretreatment options should be examined to reduce the ammonia loading to the municipal system.

Cherestea Voinesti

Cherestea Voinesti manufactures wood products and performs mechanical and chemical treatment of its wastewater. The factory's to the municipal plant has a high ammonia concentration (29 mg/L), but the flow rate is very low, at 260 cmd. Therefore, the loading to the municipal plant is low.

Autobaza

Trucks are repaired at this facility. It uses mechanical treatment but generates very little contamination.

Tabacaria

This facility is a tannery with very low flow and minimal nutrients. It operates mechanical and chemical treatment facilities.

General

Additional data needed about industrial dischargers for the feasibility study include the following:

- An analysis of the organic nitrogen content of all industrial emissions is needed to calculate the total nitrogen loading to the Cîmpulung municipal treatment plant. No such data have been located; therefore, it will be necessary to perform several analyses on each emission to obtain an accurate representation of the waste stream. Similar information on the phosphorus content of the industrial emissions is also needed for Cîmpulung.
- Emission characteristics must be related to the production process of each discharger. An accurate assessment must be made of how the emission quantity and quality would change with increased or decreased production. In addition, expected changes in production processes should also be evaluated for effects on emissions.
- Each industry should be evaluated to identify additional waste minimization opportunities.
- Institutional and facilities requirements for the implementation of spill prevention and control programs should be determined for each industry. These programs are intended to reduce the probability of spills to the WWTPs or directly to waterways.
- Chemical analysis capability is required to monitor the industrial pretreatment operations. This capability can be available through the inspectorate, the municipality, or the industries.

7.4 Estimated Costs

The strategic plan presented in Section 7.3 is summarized with pertinent estimated capital costs in Table 44.

The estimated capital costs for components of wastewater treatment plants were developed by adapting cost functions for similar facilities presented in publications published by the United States Environmental Protection Agency (EPA). The cost functions were updated to 1993 conditions by applying the *Engineering News Record* construction cost index of 5,200 to obtain an equivalent cost in the United States. This cost was converted to current Romanian market costs by applying factors to the labor, materials, and equipment components of the facilities costs, and a 20-percent contingency was added to obtain the total estimated capital costs in Romania.

Table 43

Industrial Pretreatment Requirements for Cîmpulung

Industry	Description	Flow Rate	Major Contaminant	Needs
Aro	Vehicle manufacture	8,640 cmd	Ammonia, 64 kg/day; phosphate; heavy metals	- Waste minimization - Nitrogen removal facilities - Phosphorus removal facilities - Additional metals removal - Effluent monitoring - Spill plan - Sludge management - Metals reclamation
Grulen	Synthetic fibers	2,458 cmd	Ammonia, 13 kg/day	- Waste minimization - Nitrogen removal facilities
Cherestea Voinesti	Wood products	260 cmd	Ammonia, 29 mg/L (low load)	- Minimal needs due to low contamination

Noncapital project costs for wastewater treatment plant staff and laboratory upgrading, and those for sewer system testing and repair, were estimated by providing allowances developed through team discussions.

O&M costs, shown in Table 45, were estimated by adjusting the components given by EPA cost functions for similar activities. The component costs were converted to equivalent units or quantities of man-hours, kwh of electricity, and materials. Applicable current Romanian market costs were applied to obtain the O&M values.

Table 44

Cîmpulung Municipal Wastewater Facilities—
Summary of Strategic Plan

Investment Description	When Needed	Flow or Condition Covered	Cost[a]		Comments
			Million Lei	Thousand Dollars[b]	
A) Immediate					
1) Improve existing sewer system, WWTP laboratory, and O&M.	Immediately	Existing flow = 22,300 cmd	60	100	Covers the inspection of, smoke tests of, and repairs to existing sewers; laboratory upgrade; and O&M training needs.
2) Rehabilitate digester	Immediately	Existing flow = 22,300 cmd	36	60	Rehabilitate existing digester's mechanical and electrical elements. Provide adequate capacity for one-third of 1993 flow.
3) Add new digester.	Immediately	Existing flow + 5,700 cmd total = 28,000 cmd	48	80	Additional capacity is needed for remaining two-thirds of 1993 flow (assuming item 2 above is completed). However, the additional cost to add capacity to accommodate total Phase II flow is small; therefore, size the digester for Phase II flow now.
4) Expand preliminary treatment.	Immediately	Existing flow + 15,700 cmd total = 38,000 cmd	58	97	Existing preliminary treatment is adequate for only 13,000 cmd. Therefore, 9,700 cmd capacity is needed to treat existing flows. However, the additional cost to add capacity to accommodate total Phase II flow (10,000 additional cmd) is small; therefore, size the plant for Phase II flow now.

(continued)

Table 44 (continued)

Investment Description	When Needed	Flow or Condition Covered	Cost[a]		Comments
			Million Lei	Thousand Dollars[b]	
B) Phase I					
5) Extend sewer system.	Year 2000	Existing flow + 5,700 cmd total = 28,000 cmd	36	60	Add new sewers to serve an additional 6,700 persons.
6) Add sludge thickeners.	Year 2000	Existing flow + 15,700 cmd total = 38,000 cmd	34	57	Existing thickener capacity is adequate for existing flow. Incremental cost to accommodate Phase I flow is only slightly less than to accommodate Phase II flow; therefore, size the thickeners for Phase II flow.
7) Add filter press.	Year 2000	Existing flow + 15,700 cmd total = 38,000 cmd	24	40	No existing filter press exists currently. Incremental cost to accommodate Phase I flow is only slightly less than to accommodate Phase II flow; therefore, size the press for Phase II flow.
C) Phase II					
8) Add aeration capacity.	Year 2010	Phase I + 10,000 cmd total = 38,000 cmd	104	174	Existing aeration capacity is adequate for Phase I flow (28,000 cmd). Add 10,000 cmd capacity to obtain Phase II flow (38,000 cmd).

(continued)

Table 44 (continued)

Investment Description	When Needed	Flow or Condition Covered	Cost[a]		Comments
			Million Lei	Thousand Dollars[b]	
<u>Summary</u>[c]					
A) Immediate Costs:	Immediately	Existing flow = 24,200 cmd	202	337	
Items 1 - 4					
B) Phase I Costs:	Year 2000	28,000 cmd	94	157	
Items 5 - 7					
C) Phase II Costs:	Year 2010	38,000 cmd	104	174	
Item 8					
		TOTAL	400	668	

[a] Costs represent 1993 Romanian market costs and include 20 percent contingencies.
[b] Exchange rate of 600 lei/$US 1.
[c] No costs for nitrification/denitrification or phosphorus removal are shown. Strategy is to wait until year 2000 to determine if nutrient removal is needed at all. The assimilative capacity of the stream may be adequate to remove nutrients. Nitrification/denitrification for Phase I flow is estimated at 960 million lei or $US 1.6 million (1993 basis). Based on the magnitude of this cost versus the costs for the other improvements cited, it is logical to delay this expenditure until its need is established.

Table 45
Estimated O&M Costs - Cîmpulung

Condition	Incremental O&M Costs (Million Lei/Year)	Cumulative O&M Costs (Million Lei/Year)
Existing Conditions	46	46
Immediate Improvements	19	65
Phase I Improvements	14	79
Phase II Improvements	14	93

7.5 Financial Considerations

Financing for all of the capital cost requirements for the Cîmpulung strategic plan is based upon borrowing the total amount, through loans at a 12 percent interest rate and 20 year repayment term. The cost recovery for the loan payments plus the O&M requirements are assumed to be provided through tariff charges. Thus the Cîmpulung strategic plan is assumed to be financially self-sufficient, with no direct government subsidy.

The required annual costs, average tariffs/and monthly cost for a typical household to finance the strategic plan are summarized in Table 46. The table illustrates the cost and tariff requirements for the "online conditions" of all facilities and improvements, and thus the most expensive case in terms of those system customers who will pay these costs.

Table 46 indicates that the household costs are reasonable under all investment conditions. The costs shown should be examined considering the following key assumptions:

- All costs are covered by the tariffs to produce a break-even situation; the loan conditions are for future economic conditions. National policy may allow, as is the case in many wastewater programs throughout the world, for a portion of the capital cost to be provided as a government grant. Furthermore, total financing through loans may be only one of several mechanisms available for investments (see discussion in Chapter 4).

- Tariffs are computed assuming no cross-subsidies from industrial users. If the analysis included industrial tariffs at one-half the current level (i.e., 2.8 times the domestic tariff levels), the tariffs shown in Table 46 would be reduced by 35 percent.

- Household charges are computed assuming that they are assessed by billing the individual households.

- The ability-to-pay comparison in Table 46 is based upon the January 1993 national average wage level in urban areas of 27,763 lei per month. Chapter 4 indicates that about 45 percent of Romania's workers are at wage levels above the average.

- The monthly household charges in Table 46 are shown for cost conditions representing the total investments for the design horizons for Phases I and II (years 2000 and 2010, respectively). The actual costs required may be less, as the capital costs will be spread over several years.

- The costs used to compute the tariffs do not consider any reductions in operating costs gained through the immediate improvements. Such investments in Cîmpulung's existing wastewater collection system and treatment plant, combined with those for optimizing treatment plant O&M, should cause the base O&M costs to decrease.

Table 46

Financial Impacts—Cîmpulung

	Estimated Capital Cost of Facilities Added		Additional Annual O&M Cost[c]	Total Cumulative Annual Cost	Domestic Tariff[d]	Average Monthly Cost per Household[e]	Percentage of Income	Percentage of Income of Bottom Third[f]
	Total[a]	Annual[b]						
	Million Lei	Million Lei	Million Lei	Million Lei	Lei/m³	Lei	%	%
Existing Conditions	--	--	46	46	5.7	172	0.6	0.8
Immediate Improvements	202	27	19	92	11.3	371	1.3	1.7
Phase I Improvements	94	13	14	119	11.6	422	1.5	2.0
Phase II Improvements	104	14	14	147	10.6	449	1.6	2.1

(a) From Table 44.
(b) Average annual payment to repay loan with an interest rate of 12 percent and a 20-year term.
(c) From Table 45.
(d) The tariffs are computed assuming no cross-subsidies from industrial users.
(e) Equivalent household tariff charge assuming each household was charged as an individual customer.
(f) Percent of average national wage level: January 1993 = 27,763 lei.
(g) From ability-to-pay discussion in Chapter 4.

Chapter 8

PREFEASIBILITY STUDY—CURTEA DE ARGES

8.1 General

The objectives of the wastewater prefeasibility study for Curtea de Arges were as follows:

- to identify the likely limits of the service area and the projected growth in population and wastewater flows through the year 2010;
- to develop a strategic plan for prioritized or staged rehabilitation and development of wastewater facilities, over the time periods of 1993-2000 and 2000-10;
- to estimate the costs of associated facilities, including those for municipal wastewater collection, conveyance, and treatment, and to define the requirements for industrial pretreatment facilities; and
- to examine the financial and institutional considerations in implementing the strategic plan.

These topics are considered below.

8.2 Service Area and Projected Flows

Curtea de Arges's existing sewerage system is shown in Figure 11, and a map of the existing wastewater treatment plant is depicted in Figure 12. The developed area of Curtea de Arges sits primarily on the east bank of the Arges River, in a relatively narrow and steep-sided valley. Two of the town's major industries, the Arpo porcelain factory and the Biotehnos bioprotein plant, are in the southern portion of town, on the west bank across the river from the municipal wastewater treatment plant. A slaughterhouse and the Confag clothing factory are also in the southern part of town, near the treatment plant. Other large industries are located in the northern part of Curtea de Arges, including the Electroarges radio-parts factory, the Panel and Pamuf sawmills, and the Icil dairy.

A dam has been constructed to form Lake Curtea de Arges, which lies adjacent to the center of town and precludes access and development on the west bank of the Arges. A second lake, Zigoneni, has a pool that starts immediately downstream from the discharge point of the wastewater treatment plant; algae blooms in this lake have been reported by the dam operators and the environmental inspectorate.

Curtea de Arges is a former capital of Romania and has a beautiful monastery in a unique architectural style that contains the tombs of several kings and other Romanian royalty. The town is visited by many tourists and pilgrims. It is well laid out and well maintained, with clean, wide, tree-lined streets.

Given the historic importance and touristic appeal of the community, and the topographic constraints of the valley and lake, the town should remain relatively small and compact, and the service area of the treatment plant should remain essentially the same during the next 20 years. Minor extensions to the collection system to serve future growth in population can be expected, but no major interceptors or force mains to extend the service area are anticipated.

Until 1988, the bioprotein plant in Curtea de Arges was a major source of organic pollution in the Arges basin. The plant produced a protein additive for animal feed, and employed Japanese technology designed to use paraffin from Arpechim as the feed stock. An elaborate innovative design for treating the plant's waste stream was prepared by PROED, tailored to the plant's expected effluent. Unfortunately, the supply of paraffin from Arpechim was limited, and the feed stock was changed to forage flour (a rendered meat by-product obtained from slaughterhouses).

The resulting waste stream was untreatable in the specially designed plant, and an adequate supply of suitable-quality forage flour was unavailable. As a result, the bioprotein plant is now essentially out of operation. It seems to make little economic sense to process one type of animal feed (the forage flour) to produce the originally intended additive for animal feed. Future supplies of paraffin from Arpechim are doubtful. For the purposes of this study, the WASH team assumed that the bioprotein plant will remain out of operation, and that the aeration basins and other treatment units for the bioprotein plant's waste treatment (shown in Figure 12) are potentially available to treat municipal wastewater.

The projected wastewater flows to Curtea de Arges's municipal wastewater treatment plant have been estimated from three sources of information: a PROED design report in 1974, containing flow projections to the year 1980; a questionnaire filled out by the municipality officials in 1987 outlining Curtea de Arges's water and wastewater services; and the DEMDESS data for 1992, provided by ICIM. These sources were supplemented by data provided by the environmental inspectorate in Pitesti, and by the director of the municipal enterprise based on metered flows for March 1993.

The available data were sufficient to make an approximate estimate of the existing served population, and the breakdown between domestic and industrial wastewater and infiltration. The WASH team estimated growth rates based on those from 1980 to 1992 and made nominal allowances for improved service coverage and increased per capita water use to the year 2010. As in Pitesti and Cîmpulung, industrial recovery to full production levels is assumed will occur by the year 2000, and nominal growth to the year 2010.

The resulting projected wastewater flows are shown in Table 47; they indicate an increase from 24,200 cmd at present to 43,000 cmd in the year 2010.

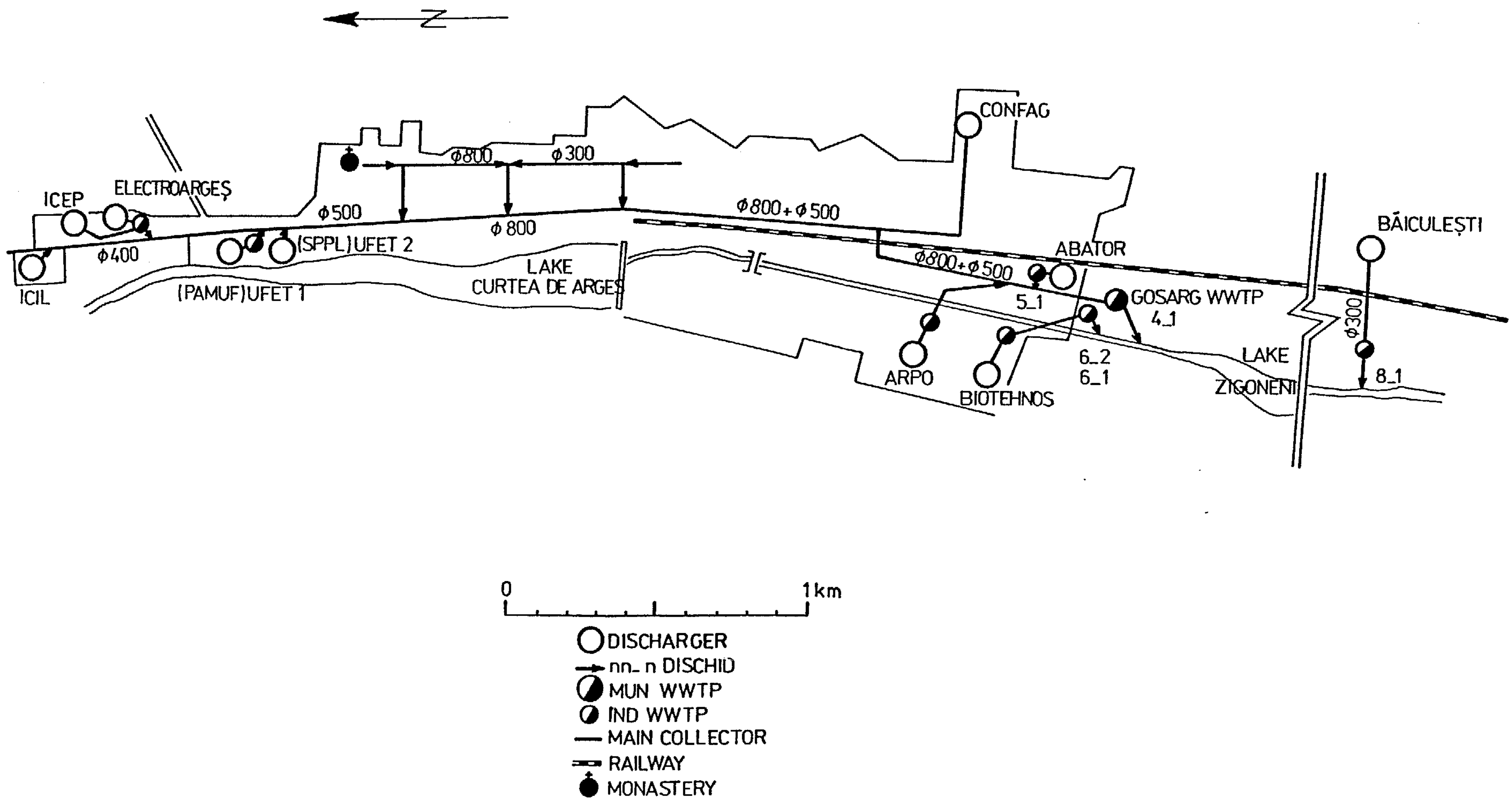

Figure 11

Curtea de Arges—Sewerage

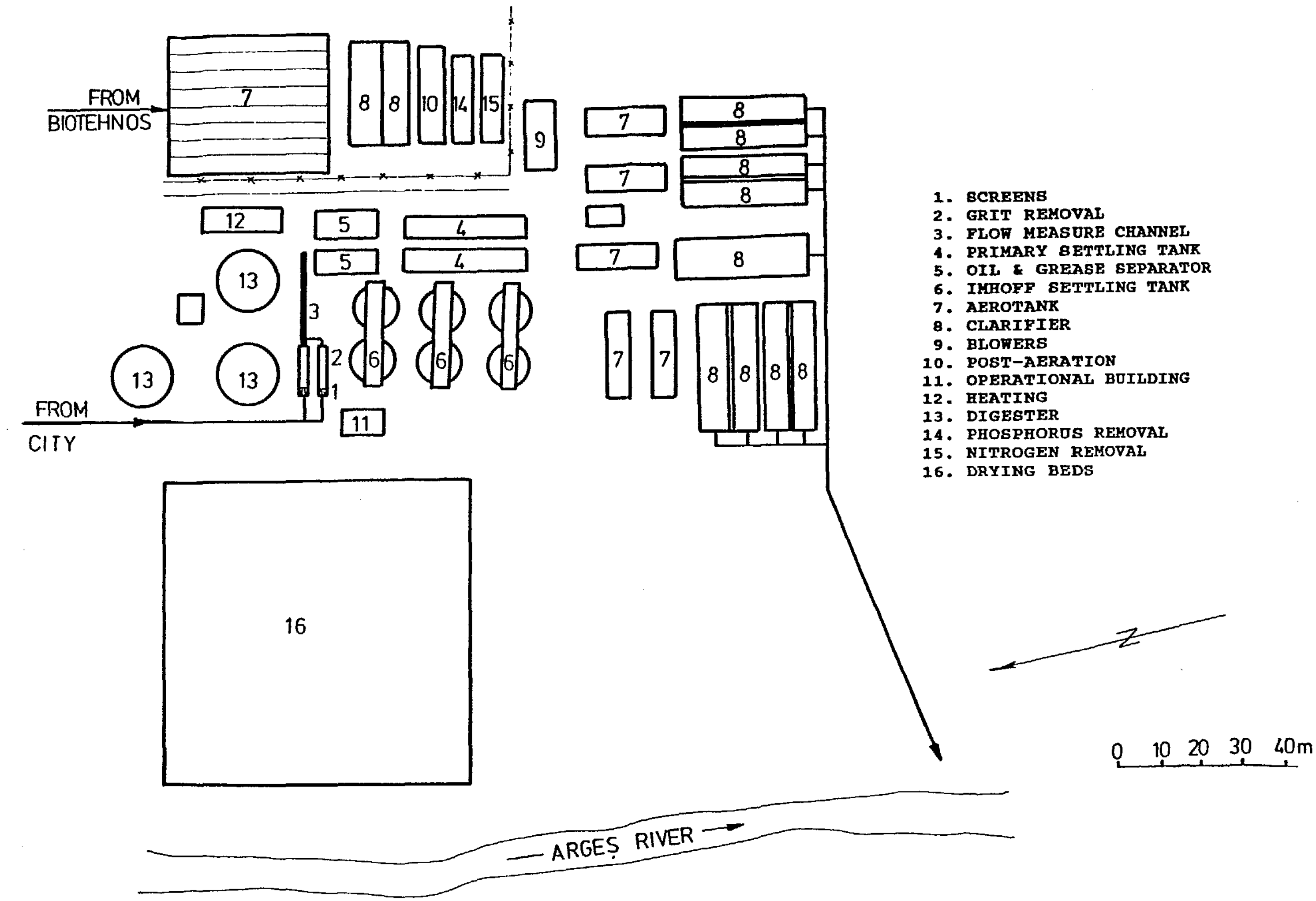

Figure 12

Curtea de Arges—Wastewater Treatment Plant

Table 47

Projected Wastewater Flows for Curtea de Arges

Year	Population		Estimated Flow (cmd)			
	Total	Served	Domestic	Industrial	Infiltration	Total
1993	35,800	25,000	9,300	9,000	5,900	24,200
2000	43,700	35,000	14,000	11,000	8,000	33,000
2010	48,300	43,500	18,300	14,800	9,900	43,000

8.3 Development of the Strategic Plan

8.3.1 Conveyance Facilities

Curtea de Arges is served by a separate sanitary sewer system, shown in Figure 11. Two parallel collectors, an old 500-mm sewer and a new 800 mm-sewer, deliver sewage to the town's treatment plant. The 500-mm collector receives substantial amounts of infiltration from the high groundwater levels along its route, particularly in the vicinity of Lake Zigoneni. The original intent was that the 800-mm sewer would be 1,200 mm in diameter, but funding limitations prevented this. Nevertheless, the WASH team assumed that the capacities of the available collectors are sufficient through the year 2010, although this assumption may rely on the reduction of infiltration into the older sewers.

The proposed improvements in conveyance facilities consist of two items: extensions to the collection system to serve additional people, and remote-camera inspection followed by rehabilitation of a portion of the sewerage system.

8.3.2 Municipal Treatment Facilities

The municipal wastewater treatment plant in Curtea de Arges is a secondary treatment plant using activated sludge. It is overloaded (hydraulic and organic capacities), and its laboratory capability is inadequate for plant operation and industrial pretreatment monitoring. Additionally, the plant's operations and maintenance (O&M) system is insufficient to maintain reliable and efficient treatment. Inadequate treatment of the town's wastewater can result in unacceptable loadings of BOD, solids, nutrients, and heavy metals to the Arges River and downstream reservoirs. Several changes can be identified for the Curtea de Arges WWTP to protect the river under existing and future wastewater flows.

Immediate Needs

The laboratory at the WWTP must be able to perform the analyses required to operate the treatment process effectively. In addition, analytical capability to detect nitrogen compounds, phosphorus, and heavy metals should be available so that the performance of the industrial pretreatment facilities can be monitored. Some of these capabilities, such as metals analysis, may be more efficient if made available at the inspectorate level.

Operator training is needed to ensure the establishment of effective O&M procedures. This training should include methods for routine process operation and monitoring; procedures for handling upsets and unusual conditions; preventive maintenance; worker safety; and record keeping. With proper operation of the treatment plant and minimization of industrial wastes, it may be possible to limit the nutrient loading to the river to acceptable levels. It is assumed that the secondary treatment facilities proposed below can be operated to minimize the phosphorus content of the effluent to the river by maximizing the phosphorus in the sludge. In addition, an industrial waste minimization program will be needed to eliminate large quantities of phosphorus and nitrogen compounds of industrial origin.

The capacity of the existing preliminary treatment train is 11,000 cmd less than the capacity of the rest of the plant. Therefore, additional bar screens and grit removal equipment are needed to bring the preliminary treatment capacity up to the current flow rate.

The municipal plant's three existing sludge digesters have such serious equipment problems that the equipment must be replaced. The heat exchange system is especially in need of replacement.

The existing activated sludge aeration tanks are undersized, as are the blowers and secondary clarifiers. An additional capacity of approximately 12,000 cmd is needed to treat the current flow of 24,200 cmd. The currently unused bioprotein treatment plant has a very large aeration capacity (tanks and blowers) because of the refractory nature of the waste it was designed to treat. However, the plant's design flow rate was only 5,200 cmd, which in part determined its small clarifier capacity. Although its aeration capacity is more than adequate for 12,000 cmd of municipal wastewater, additional clarifiers must be constructed for the municipal wastewater. In addition, the bioprotein treatment plant is up-gradient of the municipal plant; therefore, pumps and piping are needed to convey the wastewater to the bioprotein treatment plant. Arrangements should be made to obtain the use of the plant from its owners.

Sludge management is a problem at the municipal plant. The sludge drying beds are too small and cannot process sludge to a form that is attractive and easy to distribute to local farmers, or that can be disposed of in other ways. Sludge filter presses could be installed to dewater the sludge and to free some of the sludge drying bed area for the construction of the new clarifiers. Dewatered sludge should be easier to "market" to the local farmers.

Phase I Needs for the Year 2000

By the year 2000, Curtea de Arges's wastewater flow is predicted to increase by 9,000 cmd to 33,000 cmd. At that flow rate, it will be necessary to add digestion, aeration, and clarification capacity beyond the improvements proposed to meet the town's immediate needs.

Complete new digestion capacity will be needed to handle the sludge from the treatment of 9,000 cmd of wastewater. It may be possible to use some of the equipment from the bioprotein treatment plant digesters. Additionally, the aeration capacity of the bioprotein treatment plant (converted for immediate needs) should be adequate to treat the Phase I flows. It can be assumed that the pumps and piping installed to satisfy the immediate needs also are adequate for the increased Phase I flow.

The secondary clarifiers must be supplemented to settle the additional 9,000 cmd. This will require the construction of new clarifiers on newly acquired land.

Phase II Needs for the Year 2010

It is assumed that the year 2010 will bring the need for an additional 10,000 cmd of wastewater treatment capacity for a total capacity of 43,000 cmd. The added flow will require additional digestion, aeration, and clarification capacity. Additional land will be needed and must be purchased for the clarifiers; it is assumed that adequate area exists for the digester and filter press. The bioprotein treatment plant is assumed to have adequate aeration capacity, but additional pumps and piping will be needed.

8.3.3 Industrial Pretreatment Facilities

Six major industries emit wastewater to the Curtea de Arges municipal wastewater treatment plant. These industries account for a combined flow of 5,000 cmd, a BOD loading of 964 kg/day, total suspended solids (TSS) of 750 kg/day, 33 kg/day of nitrates, and 29 kg/day of ammonia. Phosphate data were unavailable. (The industrial loads are shown in Appendix B, Tables B5 and B6.) The majority of the nitrate (29 kg/day) comes from the dairy (Icil) and 19 kg/day emanates from the porcelain factory (Arpo). Electroarges has the largest flow rate at 2,160 cmd. In addition, large loadings of nitrogen compounds have been reported in the emissions from the slaughterhouse (Abator Pasari).

The following are details on the changes possible at each industry to reduce the contaminant load on the Pitesti municipal plant. For a summary of the data for the four most significant industrial polluters, see Table 48.

Abator Pasari [DEMDESS No. 5-1])

This chicken processing facility has a flow rate of 691 cmd and uses mechanical and biological wastewater treatment. Available samples of the effluent do not contain high concentrations of contaminants; however, municipal plant operators report intermittent high loadings of nitrogen compounds including ammonia at 30 mg/L from the slaughterhouse. Waste minimization measures should be identified at this plant, and nitrogen removal facilities should be considered in order to remove the slug loading on the municipal plant.

Arpo

Arpo is a porcelain manufacturer. Its wastewater flow rate is 1,356 cmd. Its contaminant loading of concern to the municipal treatment plant is primarily ammonia (14 mg/L, or 19 kg/day). The industry has mechanical wastewater treatment facilities. Measures should be investigated for waste minimization and nitrogen removal.

Electroarges

Electroarges manufactures electronic components and combines its wastewater with wastewater from the appliance manufacturer Icep. Electroarges uses mechanical and chemical treatment, and its total flow rate is 2,160 cmd. Little heavy metals contamination to the municipal system is reported; however, this should be confirmed via a comprehensive monitoring of the plant's effluent and operation. Such a monitoring program should be designed to detect spills and periodic equipment cleaning and to determine the need for waste minimization and additional pretreatment facilities. Electroarges also discharges 6.5 kg/day of ammonia to the municipal system; manufacturing process changes should be investigated to minimize that amount.

Icil

Icil is a dairy (flow, 259 cmd) that exhibits a large loading of BOD (1,750 mg/L, or 454 kg/day) and nitrate (110 mg/L, or 28.5 kg/day) to the municipal system. Waste minimization measures should be investigated here. Facilities for BOD and nitrogen removal could be constructed to reduce the load to the municipal treatment plant.

Cofarg

Cofarg is a clothing factory with dyeing operations. No major contaminants have been identified from it.

Ufet

Ufet manufactures wood products and incorporates mechanical and chemical treatment of wastewater in a total flow of 259 cmd. Its resulting emission does not contribute significant contamination to the municipal treatment plant.

General

Additional data needed about industrial dischargers for the feasibility study include the following:

- An analysis of the organic nitrogen content of all industrial emissions is needed to calculate the total nitrogen loading to the Curtea de Arges municipal treatment plant. No such data have been located; therefore, it will be necessary to perform several analyses on each emission to obtain an accurate representation of the waste stream.
- Similar information on the phosphorus content of the industrial emissions in Curtea de Arges is also needed.
- Emission characteristics must be related to the production process of each discharger. An accurate assessment must be made of how the emission quantity and quality would change with increased or decreased production. In addition, expected changes production processes should also be evaluated for effects on emissions.
- Each industry should be evaluated to identify additional waste minimization opportunities.
- Institutional and facilities requirements for the implementation of spill prevention and control programs should be determined for each industry. These programs should be intended to reduce the probability of spills to the WWTPs or directly to waterways.
- Chemical analysis capability is required to monitor industrial pretreatment operations. This capability can be made available through the inspectorate, the municipality, or the industries.

Table 48

Industrial Pretreatment Requirements for Curtea de Arges

Industry	Description	Flow Rate	Major Contaminant	Needs
Abator Pasari	Chicken processing	691 cmd	Nitrogen compounds	- Waste minimization - Nitrogen removal facilities
Arpo	Porcelain	1,356 cmd	Ammonia, 19 kg/day	- Waste minimization - Nitrogen removal facilities
Electroarges	Electronics	2,160 cmd	Heavy metals, ammonia	- Waste minimization - Effluent monitoring - Additional metals removal
Icil	Dairy	259 cmd	BOD, 454 kg/day; Nitrate, 29 kg/day	- Waste minimization - BOD removal - Nitrogen removal

8.4 Estimated Costs

The strategic plan presented in Section 8.3 is summarized with pertinent estimated capital costs in Table 49.

The estimated capital costs for components of wastewater treatment plants were developed by adapting cost functions for similar facilities presented in publications published by the United States Environmental Protection Agency (EPA). The cost functions were updated to 1993 conditions by applying the *Engineering News Record* construction cost index of 5,200 to obtain an equivalent cost in the United States. This cost was converted to current Romanian market costs by applying factors to the labor, materials, and equipment components of the facilities costs, and a 20-percent contingency was added to obtain the total estimated capital costs in Romania.

Noncapital project costs for wastewater treatment plant staff and laboratory upgrading, and those for sewer system testing and repair were estimated by providing allowances developed through team discussions.

O&M costs, shown in Table 50, were estimated by adjusting the components given by EPA cost functions for similar activities. The component costs were converted to equivalent units or quantities of man-hours, kwh of electricity, and materials. Applicable current Romanian market costs were applied to obtain the O&M values.

Table 49

Curtea de Arges Municipal Wastewater Facilities—
Summary of Strategic Plan

Investment Description	When Needed	Flow or Condition Covered	Cost[a]		Comments
			Million Lei	Thousand Dollars[b]	
A) <u>Immediate</u>					
1) Improve existing sewer system, WWTP laboratory, and O&M.	Immediately	Existing flow = 24,200 cmd	30	50	Covers the inspection of, smoke tests of, and repairs to existing sewers; laboratory upgrade; and O&M training needs.
2) Add preliminary treatment.	Immediately	Existing flow = 24,200 cmd	79	132	Add bar screens and grit removal to increase preliminary treatment capacity by 11,000 cmd to match capacity of plant as a whole.
3) Rehabilitate digester.	Immediately	Existing flow = 24,200 cmd	90	150	Repair or replace heating equipment in existing units.
4) Add aeration capacity and final settling tanks.	Immediately	Existing flow = 24,200 cmd	329	548	Use Bio-Protein treatment plant for added aeration capacity. Construct added clarifiers on part of sludge drying bed area. Costs include payment to purchase the Bio-Protein facilities; and yard piping, pumps, and clarifiers for half of total plant flow.
5) Sludge filter press.	Immediately	Existing + 9,000 cmd total = 33,200 cmd	324	540	Filter press is added for existing sludge production plus full Phase I capacity. Will free area of sludge drying beds to accommodate new clarifiers.

(continued)

Table 49 (continued)

Investment Description	When Needed	Flow or Condition Covered	Cost[a]		Comments
			Million Lei	Thousand Dollars[b]	
B) <u>Phase I</u>					
6) Extend sewer system.	Year 2000	Existing + 9,000 cmd total = 33,200 cmd	48	79	Add new sewers to serve an additional 8,800 persons.
7) Add new digesters.	Year 2000	Existing + 9,000 cmd total = 33,200 cmd	106	176	Add complete new digester to accommodate Phase I flow. Some Bio-Protein treatment plant digestion facilities may be used.
8) Add aeration capacity.	Year 2000	Existing + 9,000 cmd total = 33,200 cmd	0	0	No capital cost because Bio-Protein plant will provide sufficient aeration for full Phase I flow. Assume pumps and piping in item 4 above are adequate.
9) Add final clarifiers.	Year 2000	Existing + 9,000 cmd total = 33,200 cmd	203	339	Construct new secondary clarifiers. More land must be purchased.[c]
C) <u>Phase II</u>					
10) Extend sewer system.	Year 2010	Phase I + 10,000 cmd total = 43,200 cmd	54	90	Add new sewers to serve an additional 10,000 persons.
11) Add digester, filter press, and secondary clarifier additions.	Year 2010	Phase I + 10,000 cmd total = 43,200 cmd	510	851	Additional land is needed for clarifiers; it is assumed that adequate area exists for the digester and filter press.[c]
12) Add aeration equipment.	Year 2010	Phase I + 10,000 cmd total = 43,200 cmd	15	25	The Bio-Protein plant is assumed to have adequate aeration capacity. Capital costs are for additional pumps and piping.

(continued)

Table 49 (continued)

Investment Description	When Needed	Flow or Condition Covered	Cost[a]		Comments
			Million Lei	Thousand Dollars[b]	
Summary[d]					
A) Immediate Costs: Items 1 - 5	Immediately	Existing flow = 24,200 cmd	852	1,420	
B) Phase I Costs: Items 6 - 9	Year 2000	33,200 cmd	357	594	
C) Phase II Costs: Items 10 - 12	Year 2010	43,200 cmd	579	966	
		TOTAL	1,788	2,980	

[a] Costs represent 1993 Romanian market costs and include 20 percent for contingencies.
[b] Exchange rate of 600 lei/$US 1.
[c] Land cost included at current market estimates of $US 50,000 per hectare.
[d] No costs for nitrification, denitrification, or phosphorus removal are included; it is assumed that industrial waste minimization and improved municipal plant operation will be adequate for nutrient reduction.

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Table 50

Estimated O&M Costs for Curtea de Arges

Condition	Incremental O&M Costs (Million Lei/Year)	Total Annual O&M Costs (Million Lei/Year)
Existing Conditions	38	38
Immediate Improvements	29	67
Phase I Improvements	16	83
Phase II Improvements	16	99

8.5 Financial Considerations

Financing for all of the capital cost requirements for the Curtea de Arges strategic plan is based upon borrowing the total amount, through loans at a 12-percent interest rate and 20-year repayment term. The cost recovery for the loan payments plus the O&M requirements are assumed to be provided through tariff charges. Thus the Curtea de Arges strategic plan is assumed to be financially self-sufficient, with no direct government subsidy.

The required annual costs, average tariffs, and monthly cost for a typical household to finance the strategic plan are summarized in Table 51. The table illustrates the cost and tariff requirements for the "online conditions" of all facilities and improvements, and thus the most expensive case in terms of those system customers who will pay these costs.

Table 51 indicates that the household costs are somewhat high in terms of the percentage of income for all but the immediate improvements. However, the costs shown in the table are reasonable considering the following key assumptions:

- All costs are covered by the tariffs to produce a break-even situation; the loan conditions are for future economic conditions. National policy may allow, as is the case in many wastewater programs throughout the world, for a portion of the capital cost to be provided as a government grant. Furthermore, total financing through loans may be only one of several mechanisms available for investments (see discussion in Chapter 4).
- Tariffs are computed assuming no cross-subsidies from industrial users. If the analysis included industrial tariffs at one-half the current level (i.e., 2.5 times the domestic tariff levels), the tariffs shown in Table 51 would be reduced by about 40 percent.
- Household charges are computed assuming that they are assessed by billing individual households. The Curtea de Arges service area contains approximately 140 water meters. This indicates the urbanized character of the municipality, with most people

residing in high-rise apartment houses, with water supply service, and thus wastewater collection, being provided on an apartment block or areal basis. In such systems, it is common for management to assess individual household charges, recognizing the varying use among householders and their ability to pay.

- The ability-to-pay comparison in Table 51 is based on the January 1993 national average wage level in urban areas of 27,763 lei per month. Chapter 4 indicates that about 45 percent of Romania's workers are at wage levels above the average.

- The monthly household charges in Table 51 are shown for cost conditions representing the total investments for the design horizons for Phases I and II (years 2000 and 2010, respectively). The actual costs required may be less, as the capital costs will be spread over several years.

- The costs used to compute the tariffs do not consider any reductions in operating costs gained through the immediate improvements. Such investments in Curtea de Arges's existing wastewater collection system and treatment plant, combined with those for optimizing treatment plant O&M, should cause the base O&M costs to decrease.

Table 51

Financial Impacts—Curtea de Arges

	Estimated Capital Cost of Facilities Added		**Additional Annual O&M Cost[c]**	**Total Cumulative Annual Cost**	**Domestic Tariff[d]**	**Average Monthly Cost per Household[e]**	**Percentage of Income**	**Percentage of Income of Bottom Third[f]**
	Total[a]	Annual[b]						
	Million Lei	Million Lei	Million Lei	Million Lei	Lei/m³	Lei	%	%
Existing Conditions	--	--	38	38	4.3	256	1.0	1.3
Immediate Improvements	852	114	29	181	20.5	220	4.3	5.2
Phase I Improvements	357	48	16	245	20.3	303	4.7	5.9
Phase II Improvements	579	78	16	338	21.5	421	5.1	6.4

(a) From Table 49.
(b) Average annual payment to repay loan with an interest rate of 12% and a 20 year term.
(c) From Table 50.
(d) The tariffs are computed assuming no cross-subsidies from industrial users.
(e) Equivalent household tariff charge assuming each household was charged as an individual customer.
(f) Percent of average national wage level: January 1993 = 27,763 lei.
(g) From ability-to-pay discussion in Chapter 4.

APPENDIX A

ARGES STREAM WATER QUALITY IN 1992

AVERAGE VALUE (mg/L)

SITE I.D.	Ammonia	BOD-5	Cadmium	Calcium	Carbonate	Chloride	Chromium	COD-Cr	COD-mn	Copper	Cyanide	Detergents	Dissolved Oxygen	Extractable Substances	Flow ~~10^3m3/day~~ sec
01	0.1	2.9		63.9	172.8	19.8			6.3			0.031	9.0		14.2
02	0.1	3.2	0.0019	38.2	62.8	17.5			6.4	0.0141		0.049	9.1		18.6
03	0.1	2.8	0.0019	25.5	55.4	15.8			5.8	0.0059		0.073	9.3		20.7
04	0.1	3.4	0.0013	20.1	51.9	18.9			6.0	0.0095		0.087	9.2		15.5
05.01	0.1	3.3		57.8	127.1	23.9			7.1			0.045	9.0		0.8
05.02	0.1	3.2		43.6	89.0	23.9			6.5			0.044	9.3		0.5
06.01	0.2	3.4	0.0010	45.9	125.0	34.0			7.7	0.0058		0.046	9.3		4.7
06.02.01	0.2	3.2	0.0016	40.3	108.3	29.2			6.4	0.0030		0.076	9.0		3.3
06.02.03	0.1	2.9		25.4	43.2	15.1			5.2	0.0015		0.041	9.4		1.4
06.03	0.1	3.1		58.5	117.4	26.6			6.0	0.0050		0.046	9.2		1.1
06.04	0.1	3.4		43.8	71.7	17.4			6.5			0.056	9.2		1.0
07	0.2	3.3	0.0015	32.2	94.6	24.8			7.3	0.0039		0.062	9.0		17.0
08	0.4	3.4	0.0014	31.0	89.5	32.5			7.1	0.0077		0.057	8.7		23.9
09	0.3	2.6		35.5	128.1	30.0	0.0046		5.1		0.0001	0.070	8.6	0.04	19.7
10.01	1.0	4.3		130.3	383.2	340.0	0.0021		12.2		0.0234	0.082	7.1	0.06	4.8
10.02.01	2.7	7.0		52.9	232.5	143.1	0.0008		13.1		0.0693	0.104	7.2	0.07	2.3
10.02.02	8.3	12.9	0.0350	38.8	147.0	127.5			22.2	0.0315	0.0307	0.181	4.1		1.4
10.02.03	0.8	5.7		29.6	106.1	34.4			11.2	0.0050		0.080	7.5		0.4
10.03	0.9	9.4		91.9	276.5	1371.0	0.0066		11.1		0.0002	0.076	7.9	0.04	3.2
10.04	3.0	4.3		121.4	283.5	98.9			4.3			0.070	8.0	0.62	0.8
11.01	6.8	22.1		81.8	339.3	121.0			23.7			0.126	3.2		9.9
11.02	0.4	2.5		90.4	234.5	289.1	0.0018		5.4		0.0001	0.058	9.0	0.06	0.8
12	3.3			60.0	258.5	86.8	0.0289	152.2	14.5	0.0097	0.0194	0.416	2.2		26.2
13.01	3.8			60.2	252.4	90.1	0.0410	174.1	13.7	0.0316	0.0272	0.381	2.4		25.3
13.02.01	1.3	5.8		62.0	269.9	93.6			10.3			0.067	9.7		0.2
13.02.02	2.0	7.9		71.9	285.2	132.5			11.6			0.069	11.2		1.3
13.02.03	1.9	6.9		72.8	259.4	135.3			8.8				12.0		1.5
13.02.04	1.0	3.4		113.9	272.3	39.0			3.5			0.027	8.6	0.67	0.1
13.03	0.6	3.7		73.6	203.2	28.5			3.0			0.091	9.2	0.50	7.3
13.04		2.1		54.7	146.4	21.8			1.6				10.2		7.2
13.05	0.2	2.6		16.0	39.1	12.7			5.5			0.023	9.3		4.3
14	2.8			63.5	260.6	105.8	0.0301	144.3	12.4		0.0129	0.303	3.6		25.7

AVERAGE VALUE (mg/L) (continued)

SITE I.D.	Hardness	Iron	Lead	Magnesium	Manganese	Mercury	Nickel	Nitrates	Nitrites	pH	Phenols	Phosphates	Sodium	Sulphate	Total Solids	TSS	Zinc
01	11.9	0.190		13.0	0.0512			1.2	0.026	n/a		0.021	14.4	67.2	356	37	
02	6.7	0.202	0.0060	8.5	0.1300			1.4	0.033	n/a		0.031	8.4	60.4	196	26	0.005
03	4.8	0.254	0.0110	5.4	0.1947			1.3	0.087	n/a		0.037	7.2	30.8	143	33	0.012
04	4.1	0.168	0.0110	5.6	0.1898			1.5	0.042	n/a		0.031	6.0	20.4	123	27	0.009
05.01	11.8	0.106		16.6				1.0	0.022	n/a		0.046	14.1	101.5	354	69	
05.02	8.6	0.093		12.1	0.0400			0.9	0.023	n/a		0.027	10.6	73.6	261	37	
06.01	9.2	0.184	0.0490	11.7				1.8	0.099	n/a		0.092	18.4	50.9	300	43	0.009
06.02.01	8.1	0.197	0.0110	10.2	0.0100			1.5	0.104	n/a	0.001	0.080	17.4	43.9	251	32	0.011
06.02.03	5.2	0.093		6.9	0.0100			1.3	0.020	n/a		0.026	5.3	27.3	139	27	0.008
06.03	11.2	0.158		14.1				0.7	0.030	n/a		0.024	12.2	83.4	316	30	
06.04	8.4	0.105		8.7				1.0	0.064	n/a		0.027	7.6	67.8	221	27	
07	6.0	0.189	0.0085	7.0	0.1332			1.1	0.090	n/a		0.031	13.4	30.0	210	39	0.012
08	5.9	0.199	0.0440	8.5	0.0200			1.3	0.080	n/a		0.056	14.0	35.3	210	43	0.005
09	6.7	0.148		8.2	0.6030	0.0001		4.4	0.208	n/a	0.003	0.050	21.5	27.9	207	30	
10.01	18.2	0.292		37.3	0.1734			5.4	0.970	n/a	0.009	0.412	229.0	57.7	972	29	
10.02.01	10.9	0.337		15.1	0.1814			6.0	0.827	n/a	0.013	0.323	100.7	34.1	512	40	
10.02.02	7.7	0.506		7.8	0.0100			1.1	0.168	n/a	0.159	0.118	94.1	57.7	481	83	0.015
10.02.03	6.3	0.870		9.5	0.0100			1.2	0.064	n/a		0.155	17.5	32.5	244	103	0.005
10.03	20.5	0.169		30.7	0.1859			6.8	0.516	n/a	0.003	0.458	386.7	59.9	1419	27	
10.04	21.1	0.248		17.6				0.8	0.247	n/a		0.332	36.8	110.8	547	91	
11.01	18.8			26.6				6.1	0.603	n/a	0.049		103.3	111.9	586	106	
11.02	16.6	0.171		17.1	0.1919			4.1	0.289	n/a	0.040	0.122	155.8	48.5	772	91	
12	14.4	0.136	0.0221	21.6	0.2316		0.267	1.4	0.454	n/a	0.226	0.280	64.0	84.3	702	315	
13.01	14.7	0.154	0.0330	20.1	0.2829		0.283	1.8	0.482	n/a	0.282	0.359	71.1	78.9	716	296	
13.02.01	14.7			25.4				3.7	0.098	n/a	0.012	0.130	88.7	93.9	454	76	
13.02.02	14.8			20.4				4.4	0.144	n/a	0.014	0.292	118.4	95.2	527	58	
13.02.03	14.9			20.7				3.7	0.219	n/a		0.202	108.5	96.2	520	60	
13.02.04	19.0	0.159		13.5	0.0390			0.8	0.248	n/a		0.067	14.8	94.9	449	58	
13.03	13.8	0.202		15.3				0.7	0.145	n/a		0.033	9.2	80.6	338	72	
13.04	10.1	0.163		10.7				0.7	0.092	n/a			5.7	56.2	241	45	
13.05	3.6	0.119		9.2				1.3	0.020	n/a		0.037	3.6	18.8	98	22	
14	14.3	0.136	0.0652	22.6	0.2242		0.288	1.4	0.411	n/a	0.173	0.331	74.0	81.9	710	293	

NUMBER OF SAMPLES

SITE I.D.	Ammonia	BOD-5	Cadmium	Calcium	Carbonate	Chloride	Chromium	COD-Cr	COD-mn	Copper	Cyanide	Detergents	Dissolved Oxygen	Extractable Substances	Flow ~~10^3m3/day~~ sec
01	4	12		11	10	5			10			5	10		11
02	5	10	4	11	7	6			8	7		10	9		12
03	6	11	4	8	8	7			9	6		6	11		12
04	4	10	3	8	7	6			11	5		8	9		12
05.01	5	9		11	8	8			11			7	11		9
05.02	4	8		11	8	7			11			8	12		9
06.01	4	11	3	9	7	7			7	5		7	11		11
06.02.01	7	10	4	12	10	6			9	5		7	10		12
06.02.03	5	10		10	5	5			11	3		6	12		10
06.03	5	8		11	8	6			11	1		8	11		12
06.04	5	11		10	9	7			10			7	10		10
07	5	9	3	12	9	8			11	4		8	10		12
08	8	12	3	10	9	7			11	3		7	9		12
09	9	10		11	11	10	7		11		1	10	10	7	11
10.01	11	11		11	11	11	6		11		5	11	10	10	10
10.02.01	10	10		11	9	11	5		11		5	10	10	9	6
10.02.02	11	12	1	12	11	11			11	2	7	10	10		7
10.02.03	7	8		10	8	8			10	1		5	10		4
10.03	9	11		11	10	11	5		11		2	10	10	10	10
10.04	4	12		12	12	12			12			9	12	3	11
11.01	11	9		11	11	9			11			9	11		5
11.02	8	11		11	10	11	4		11		2	10	10	8	11
12	12			11	10	12	8	8	12	1	10	6	12		9
13.01	12			12	10	12	8	8	12	1	11	6	12		10
13.02.01	11	10		10	11	11			10			9	11		6
13.02.02	10	10		10	10	10			10			8	10		5
13.02.03	9	10		10	9	10			10				10		8
13.02.04	2	12		11	11	12			12			5	12	3	8
13.03	4	12		10	10	11			11			5	12	2	12
13.04		12		12	7	12			10				12		12
13.05	4	9		8	6	4			11			5	11		11
14	12			12	12	12	8	8	12		10	6	11		11
Total	223	300	25	340	294	285	51	24	339	44	53	228	341	52	311

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NUMBER OF SAMPLES (continued)

SITE I.D.	Hardness	Iron	Lead	Magnesium	Manganese	Mercury	Nickel	Nitrates	Nitrites	pH	Phenols	Phosphates	Sodium	Sulphate	Total Solids	TSS	Zinc
01	11	7		10	1			8	10	10		6	10	12	12	9	
02	10	9	1	9	7			8	10	9		6	12	9	12	8	4
03	11	9	1	9	7			5	9	9		7	11	8	12	9	5
04	10	7	1	7	9			7	9	8		7	11	7	12	7	6
05.01	12	7		9				8	8	6		7	11	12	12	9	
05.02	11	4		8	1			6	8	10		8	11	9	12	9	
06.01	11	6	1	8				7	10	8		12	12	11	12	9	6
06.02.01	11	9	1	10	1			6	11	9	1	10	10	8	11	10	5
06.02.03	11	4		7	1			8	8	11		7	9	9	12	10	2
06.03	9	8		10				8	10	8		7	12	11	12	9	
06.04	11	6		10				5	9	7		7	11	10	12	9	
07	11	6	2	9	4			5	9	10		10	12	8	12	8	5
08	10	8	1	10	1			6	11	9		11	12	8	12	6	7
09	9	10		9	7	1		9	11	3	2	9	11	10	11	10	
10.01	11	10		11	6			10	11	4	7	11	11	11	11	11	
10.02.01	11	11		10	5			8	11	4	9	11	11	11	11	10	
10.02.02	10	9		7	1			7	10	9	9	9	12	9	12	11	1
10.02.03	10	9		6	1			7	7	8		8	9	10	10	8	1
10.03	11	11		11	5			8	11	3	4	11	11	10	11	10	
10.04	12	10		12				11	12	5		5	12	12	12	12	
11.01	11			11				11	11	1	9		8	11	11	10	
11.02	10	10		11	4			6	11	4	1	11	11	10	11	11	
12	11	4	4	12	10		5	10	12	11	6	6	8	12	10	10	
13.01	12	4	4	12	10		4	10	12	12	6	6	8	12	10	10	
13.02.01	9			11				11	11	1	7	11	10	11	11	9	
13.02.02	9			10				9	8	1	9	9	8	10	10	10	
13.02.03	10			9				10	9	1		7	8	10	10	10	
13.02.04	11	9		11	1			11	10	4		3	10	12	12	11	
13.03	12	10		12				12	11	5		3	10	12	11	12	
13.04	12	5		12				11	7	2			10	12	12	12	
13.05	10	6		9				8	7	9		10	8	7	11	10	
14	12	4	5	12	10		5	10	12	11	6	6	8	12	10	10	
Total	342	212	21	314	92	1	14	266	316	212	76	241	328	326	362	309	42

Total Number of Samples = 6384

MAXIMUM VALUE (mg/L)

SITE I.D.	Ammonia	BOD-5	Cadmium	Calcium	Carbonate	Chloride	Chromium	COD-Cr	COD-mn	Copper	Cyanide	Detergents	Dissolved Oxygen	Extractable Substances	Flow ~~10^3m3/day~~ sec
01	0.5	4.2		102.5	213.5	74.5			11.9			0.087	11.7		66.8
02	0.2	4.9	0.0030	84.9	122.0	71.0			8.2	0.0280		0.087	10.4		67.1
03	0.3	4.0	0.0030	60.9	97.6	42.6			8.8	0.0100		0.125	10.7		62.8
04	0.2	4.3	0.0020	57.7	97.6	53.2			9.4	0.0190		0.162	10.4		42.0
05.01	0.2	4.9		91.3	170.8	60.3			9.8			0.087	11.4		1.9
05.02	0.4	4.4		68.9	115.9	106.5			10.9			0.087	11.7		1.2
06.01	0.4	4.5	0.0015	56.1	146.4	71.0			10.0	0.0140		0.087	11.1		7.6
06.02.01	0.5	5.8	0.0025	89.7	152.5	70.0			11.4	0.0048		0.162	11.5		7.1
06.02.03	0.2	4.8		102.5	85.4	53.0			8.2	0.0020		0.087	11.9		3.6
06.03	0.2	4.0		96.1	146.4	102.9			9.8	0.0050		0.080	11.8		2.0
06.04	0.3	6.8		88.1	103.7	46.1			11.7			0.112	11.8		2.4
07	0.8	6.8	0.0020	51.3	134.2	56.8			14.5	0.0048		0.112	11.6		53.6
08	1.6	5.0	0.0020	44.8	134.2	71.0			10.1	0.0096		0.087	10.9		35.1
09	0.6	5.2		50.3	158.6	36.6	0.0090		7.0		0.0001	0.120	11.3	0.05	35.9
10.01	2.4	6.1		754.3	538.8	498.7	0.0050		16.0		0.0670	0.120	10.7	0.11	6.2
10.02.01	4.9	19.0		68.0	274.5	282.4	0.0020		16.8		0.1430	0.204	10.2	0.09	2.7
10.02.02	30.6	28.0	0.0350	52.8	244.0	266.2			32.2	0.0560	0.0970	0.300	5.8		1.8
10.02.03	1.8	7.9		62.5	158.6	75.6			17.3	0.0050		0.112	9.4		1.7
10.03	2.6	67.6		146.7	313.1	8666.7	0.0180		17.1		0.0003	0.153	10.4	0.07	4.6
10.04	5.8	8.9		148.6	380.2	160.4			6.1			0.210	11.3	1.00	1.8
11.01	17.2	33.0		111.7	514.2	172.6			36.3			0.151	7.7		12.0
11.02	0.6	5.1		116.0	260.3	547.1	0.0051		8.5		0.0002	0.163	12.1	0.10	1.3
12	11.4			95.2	284.6	111.2	0.0401	296.9	22.6	0.0097	0.0440	0.516	6.7		38.5
13.01	15.2			102.7	294.8	118.2	0.0911	342.2	24.2	0.0316	0.0468	0.582	6.4		33.7
13.02.01	2.2	8.8		82.0	309.1	128.9			16.7			0.098	12.6		0.5
13.02.02	3.2	15.5		98.3	347.7	182.0			15.8			0.095	22.9		3.7
13.02.03	3.5	12.4		98.9	347.7	193.7			15.1				17.9		3.7
13.02.04	1.1	5.0		128.0	372.1	109.6			6.1			0.070	10.6	1.00	0.3
13.03	0.9	5.6		129.3	315.2	60.7			5.9			0.187	12.2	0.67	9.5
13.04		3.8		120.2	227.7	76.6			2.4				12.6		11.6
13.05	0.5	3.7		28.8	91.5	53.0			9.4			0.037	11.9		8.2
14	8.7			95.7	292.8	152.1	0.0486	319.2	17.9		0.0308	0.408	8.3		33.8

MAXIMUM VALUE (mg/L) (continued)

SITE I.D.	Hardness	Iron	Lead	Magnesium	Manganese	Mercury	Nickel	Nitrates	Nitrites	pH	Phenols	Phosphates	Sodium	Sulphate	Total Solids	TSS	Zinc
01	17.4	0.357		31.6	0.0512			4.0	0.062	8.0		0.080	40.0	139.2	516	196	
02	15.2	0.357	0.0060	21.8	0.2560			2.2	0.106	7.7		0.160	27.6	147.4	445	48	0.010
03	9.8	0.447	0.0110	10.9	0.5000			2.8	0.600	8.3		0.200	27.6	96.0	296	72	0.025
04	9.4	0.357	0.0110	13.3	0.5100			2.8	0.220	7.9		0.080	12.8	67.2	262	60	0.015
05.01	19.7	0.244		52.2				1.8	0.056	8.0		0.178	36.0	249.6	556	404	
05.02	13.6	0.179		31.6	0.0400			1.4	0.056	7.8		0.130	24.7	124.8	445	120	
06.01	11.8	0.270	0.0490	26.7				3.0	0.237	8.0		0.309	37.0	129.6	378	84	0.027
06.02.01	21.9	0.313	0.0110	41.3	0.0100			2.0	0.370	8.3	0.001	0.298	57.5	117.2	423	60	0.026
06.02.03	21.9	0.178		32.8	0.0100			2.6	0.060	7.5		0.090	34.5	126.0	333	60	0.014
06.03	17.4	0.313		29.1				1.4	0.087	8.0		0.060	24.7	163.0	436	60	
06.04	13.8	0.244		21.8				1.8	0.280	7.8		0.049	12.7	153.6	374	72	
07	8.9	0.312	0.0110	10.9	0.2560			2.2	0.310	8.0		0.089	46.0	48.0	319	80	0.018
08	8.1	0.357	0.0440	17.2	0.0200			2.6	0.160	7.7		0.097	46.0	139.2	285	88	0.010
09	8.6	0.410		12.6	4.8600	0.0001		11.2	0.450	8.0	0.005	0.113	35.6	48.0	266	53	
10.01	22.4	0.745		52.3	0.4780			14.8	3.490	8.5	0.030	1.510	322.8	202.4	1159	40	
10.02.01	14.8	0.608		23.1	0.4740			12.9	3.290	8.0	0.040	0.530	188.8	65.5	792	64	
10.02.02	11.6	0.983		20.6	0.0100			2.6	0.600	8.2	0.890	0.400	180.0	98.0	815	172	0.015
10.02.03	10.7	3.700		15.8	0.0100			2.4	0.187	7.6		0.400	52.9	91.2	398	182	0.005
10.03	30.3	0.380		49.6	0.5420			17.2	1.020	8.5	0.005	0.860	860.0	141.9	2815	33	
10.04	30.3	0.420		41.2				1.7	0.960	7.9		0.750	68.3	189.8	844	123	
11.01	27.4			50.5				16.5	1.725	7.0	0.087		133.4	149.5	694	167	
11.02	18.3	0.341		35.6	0.5940			8.3	0.753	8.5	0.040	0.570	318.9	96.7	1147	630	
12	21.3	0.161	0.0460	37.1	0.3677		0.372	3.7	1.140	7.6	0.369	0.952	93.7	207.0	893	416	
13.01	20.9	0.197	0.0560	31.1	0.4682		0.299	4.8	0.977	8.0	0.478	1.432	116.6	121.0	913	349	
13.02.01	16.6			33.9				13.7	0.220	7.0	0.022	0.610	118.5	105.6	491	131	
13.02.02	18.3			33.2				11.1	0.320	7.0	0.027	0.700	145.0	120.9	722	116	
13.02.03	17.8			40.3				11.8	0.430	7.0		0.510	151.1	115.3	723	107	
13.02.04	20.7	0.240		20.7	0.0390			2.0	1.130	7.9		0.130	39.0	166.8	510	78	
13.03	21.1	0.470		28.5				1.3	0.800	7.9		0.047	20.3	153.6	504	138	
13.04	18.8	0.207		22.5				1.2	0.310	7.0			19.7	114.7	423	81	
13.05	5.8	0.236		48.0				4.2	0.093	7.4		0.160	23.0	52.8	166	60	
14	20.8	0.167	0.2720	38.1	0.3761		0.421	3.6	1.490	7.6	0.294	0.916	106.7	188.1	871	373	

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MINIMUM VALUE (mg/L)

SITE I.D.	Ammonia	BOD-5	Cadmium	Calcium	Carbonate	Chloride	Chromium	COD-Cr	COD-mn	Copper	Cyanide	Detergents	Dissolved Oxygen	Extractable Substances	Flow ~~10^3~~m3/~~day~~ Sec
01	0.0	1.6		12.8	36.6	7.1			3.1			0.013	7.0		1.0
02	0.0	2.4	0.0010	14.4	28.0	7.1			3.7	0.0019		0.013	7.2		0.2
03	0.0	1.9	0.0010	8.0	24.4	5.3			3.5	0.0019		0.025	7.4		1.0
04	0.0	2.6	0.0010	9.6	24.4	7.1			3.5	0.0019		0.025	7.2		1.0
05.01	0.1	2.2		16.0	61.0	7.1			3.7			0.013	7.1		0.1
05.02	0.1	1.8		14.4	42.7	7.1			3.5			0.013	7.8		0.1
06.01	0.1	2.1	0.0005	32.0	109.8	17.7			5.6	0.0009		0.013	7.2		0.4
06.02.01	0.1	2.0	0.0010	20.5	61.0	10.6			4.4	0.0015		0.025	7.0		1.1
06.02.03	0.0	2.0		11.2	30.5	7.1			3.1	0.0009		0.013	7.1		0.4
06.03	0.0	1.6		19.2	79.3	10.6			3.2	0.0050		0.013	7.1		0.4
06.04	0.0	2.1		19.2	48.8	7.1			3.8			0.013	7.2		0.4
07	0.1	2.4	0.0010	11.2	48.8	10.6			4.0	0.0020		0.025	6.8		4.0
08	0.1	2.1	0.0010	16.0	54.9	17.7			4.1	0.0040		0.031	6.0		3.4
09	0.1	1.1		21.3	83.4	17.7	0.0001		3.7		0.0001	0.033	6.3	0.02	11.6
10.01	0.2	2.1		38.0	309.1	242.2	0.0001		7.8		0.0001	0.049	2.5	0.00	3.2
10.02.01	0.4	2.6		40.3	166.7	78.0	0.0001		8.3		0.0001	0.035	2.3	0.00	2.1
10.02.02	0.3	6.4	0.0350	24.0	61.0	71.0			12.3	0.0192	0.0024	0.075	1.6		0.2
10.02.03	0.2	2.8		14.4	48.8	14.2			3.2	0.0050		0.062	5.4		0.0
10.03	0.2	1.2		48.0	221.6	150.1	0.0001		4.3		0.0001	0.037	3.4	0.00	2.5
10.04	1.2	2.3		82.8	166.7	11.4			1.8			0.013	5.9	0.33	0.4
11.01	1.2	11.1		37.9	205.4	82.7			8.6			0.090	0.6		3.4
11.02	0.1	0.5		50.7	183.0	174.9	0.0001		3.6		0.0001	0.010	6.0	0.01	0.2
12	0.5			49.9	229.7	57.8	0.0152	54.7	9.8	0.0097	0.0084	0.330	0.3		6.4
13.01	0.2			49.9	229.7	60.1	0.0210	56.4	8.7	0.0316	0.0092	0.206	0.3		14.1
13.02.01	0.4	2.5		47.5	211.5	70.7			5.7			0.047	5.7		0.1
13.02.02	0.3	4.2		50.7	199.2	92.2			4.4			0.043	5.1		0.1
13.02.03	0.4	2.9		56.6	213.5	102.8			5.8				7.8		0.1
13.02.04	0.9	2.2		89.0	33.5	21.1			1.3			0.010	7.0	0.33	0.0
13.03	0.3	1.4		56.6	146.4	16.1			0.6			0.010	6.7	0.33	2.8
13.04		1.1		35.0	126.1	7.7			0.1				7.9		3.2
13.05	0.1	2.0		9.6	24.4	7.1			3.1			0.012	7.1		0.5
14	0.1			51.2	205.3	1.0	0.0140	47.6	7.3		0.0044	0.135	0.8		10.3

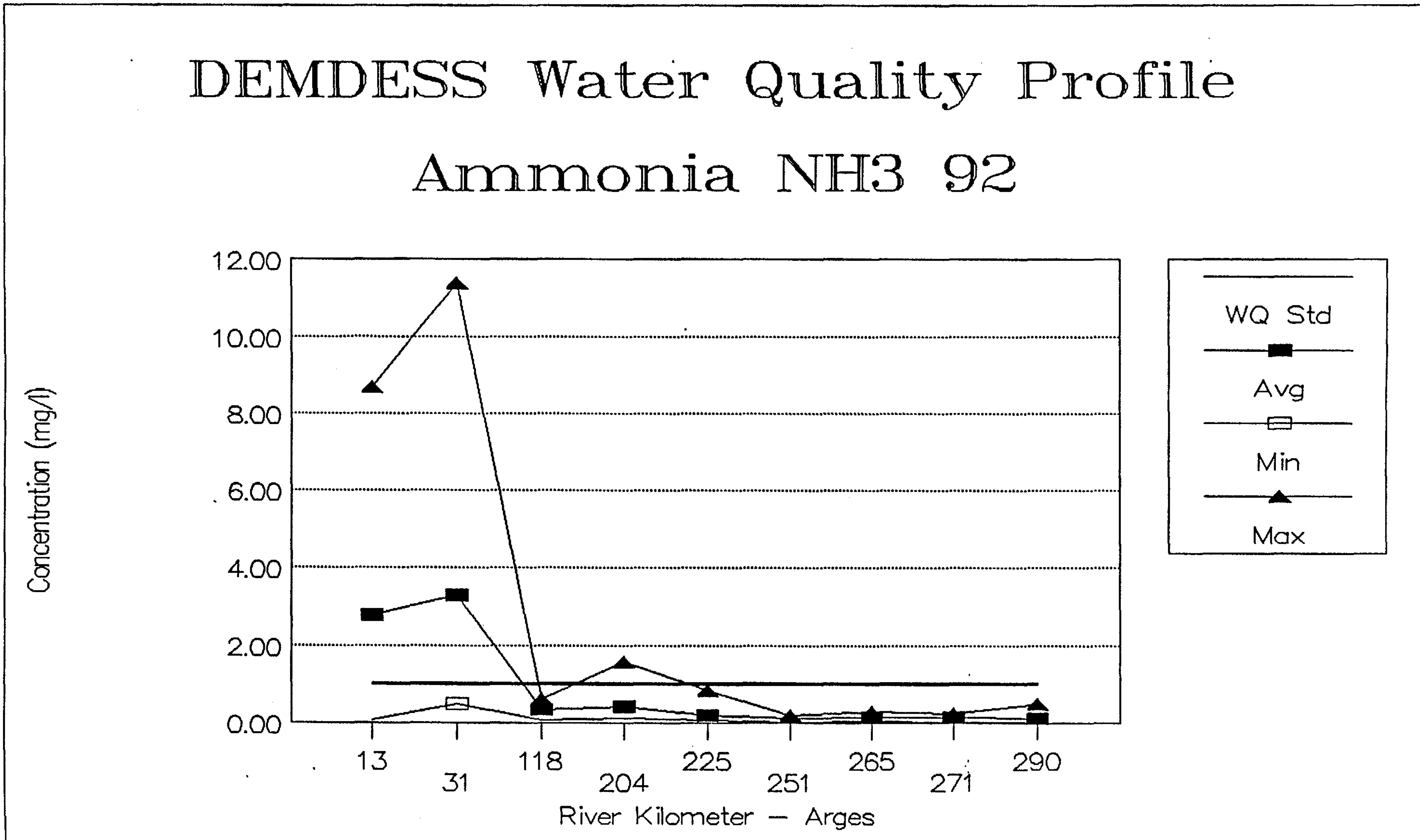
MINIMUM VALUE (mg/L) (continued)

SITE I.D.	Hardness	Iron	Lead	Magnesium	Manganese	Mercury	Nickel	Nitrates	Nitrites	pH	Phenols	Phosphates	Sodium	Sulphate	Total Solids	TSS	Zinc
01	2.5	0.045		3.6	0.0512			0.3	0.006	6.9		0.008	1.3	9.6	76	4	
02	2.6	0.084	0.0060	1.2	0.0400			0.4	0.004	6.9		0.002	1.7	9.6	74	12	0.001
03	1.3	0.089	0.0110	1.2	0.0800			0.2	0.006	6.7		0.008	1.2	4.8	56	16	0.002
04	2.0	0.005	0.0110	1.2	0.0420			0.7	0.006	6.9		0.008	2.1	4.8	57	16	0.001
05.01	4.9	0.005		6.1				0.1	0.006	7.2		0.008	6.4	33.6	190	12	
05.02	2.4	0.045		1.2	0.0400			0.1	0.006	6.9		0.003	4.8	4.8	124	12	
06.01	6.7	0.089	0.0490	3.6				1.2	0.006	7.2		0.016	9.7	9.2	214	20	0.001
06.02.01	5.4	0.045	0.0110	2.4	0.0100			0.2	0.019	6.9	0.001	0.009	8.7	14.4	179	4	0.002
06.02.03	2.2	0.005		1.2	0.0100			0.2	0.006	6.5		0.007	1.3	4.8	72	8	0.001
06.03	5.6	0.045		4.8				0.1	0.006	7.1		0.002	6.7	43.2	229	12	
06.04	4.5	0.045		2.4				0.1	0.006	7.0		0.008	1.4	7.7	130	8	
07	2.7	0.089	0.0060	1.2	0.0700			0.2	0.018	6.8		0.003	4.1	9.6	107	16	0.010
08	3.4	0.089	0.0440	2.4	0.0200			0.6	0.006	7.0		0.004	5.1	4.8	128	16	0.001
09	4.7	0.013		4.9	0.0001	0.0001		1.1	0.026	7.0	0.001	0.013	13.2	10.4	113	8	
10.01	15.1	0.060		23.1	0.0001			1.4	0.053	7.5	0.003	0.089	121.8	18.4	742	15	
10.02.01	8.7	0.049		8.9	0.0001			0.5	0.050	7.0	0.003	0.149	48.7	15.2	363	21	
10.02.02	5.1	0.134		3.6	0.0100			0.2	0.006	7.0	0.010	0.024	33.6	19.2	294	16	0.015
10.02.03	3.8	0.136		6.0	0.0100			0.2	0.030	7.1		0.040	6.6	4.8	147	20	0.005
10.03	12.9	0.112		15.8	0.0001			2.6	0.073	7.5	0.001	0.157	94.4	27.0	512	17	
10.04	14.3	0.130		5.5				0.3	0.027	6.5		0.140	7.7	48.3	311	38	
11.01	14.8			12.0				0.5	0.024	7.0	0.028		52.1	61.1	448	56	
11.02	14.1	0.056		5.7	0.0001			0.0	0.046	7.0	0.040	0.009	90.3	18.3	543	11	
12	11.8	0.120	0.0102	12.8	0.1029		0.164	0.2	0.059	6.1	0.001	0.025	30.8	55.7	589	240	
13.01	10.6	0.110	0.0152	11.5	0.1091		0.276	0.1	0.043	6.4	0.001	0.024	30.3	52.6	640	193	
13.02.01	13.3			15.0				0.7	0.027	7.0	0.006	0.016	70.6	82.6	379	40	
13.02.02	12.2			15.3				0.7	0.011	7.0	0.006	0.020	89.6	76.1	409	10	
13.02.03	11.1			11.2				1.2	0.057	7.0		0.025	76.7	81.3	407	13	
13.02.04	15.6	0.067		5.2	0.0390			0.4	0.035	6.5		0.030	5.0	50.9	349	38	
13.03	11.5	0.087		9.2				0.4	0.037	6.5		0.023	4.7	29.1	270	36	
13.04	7.0	0.063		6.8				0.3	0.025	6.5			1.7	25.5	168	25	
13.05	2.0	0.045		1.2				0.4	0.006	6.6		0.008	1.3	4.8	63	4	
14	11.4	0.085	0.0076	13.1	0.0749		0.126	0.1	0.056	6.3	0.000	0.028	29.3	53.8	633	198	

PARMETER NAME	km	RIVER NAME	LARGEST VALUE AT SITE	# OF VALUES ABOVE DW STD.	ICIM SITE ID
COD-mn	290	Arges	11.900	1	01
Iron Fe	290	Arges	.357	1	01
Iron Fe	271	Arges	.357	2	02
Manganese Mn	271	Arges	.256	3	02
Iron Fe	265	Arges	.447	4	03
Manganese Mn	265	Arges	.500	4	03
Iron Fe	251	Arges	.357	1	04
Manganese Mn	251	Arges	.510	5	04
COD-mn	225	Arges	14.500	1	07
Iron Fe	225	Arges	.312	1	07
Manganese Mn	225	Arges	.256	2	07
Ammonia NH3	204	Arges	1.560	1	08
COD-mn	204	Arges	10.100	1	08
Iron Fe	204	Arges	.357	2	08
Iron Fe	118	Arges	.410	2	09
Manganese Mn	118	Arges	4.860	5	09
Nitrates NO3	118	Arges	11.200	1	09
Phenols	118	Arges	.005	1	09
Ammonia NH3	31	Arges	11.390	5	12
COD-mn	31	Arges	22.640	11	12
Cyanide, total (CN)	31	Arges	.044	8	12
Manganese Mn	31	Arges	.368	10	12
Nickel	31	Arges	.372	5	12
Nitrites	31	Arges	1.140	1	12
Phenols	31	Arges	.369	5	12
Ammonia NH3	13	Arges	8.690	4	14
COD-mn	13	Arges	17.850	9	14
Cyanide, total (CN)	13	Arges	.031	6	14
Lead Pb	13	Arges	.272	1	14
Manganese Mn	13	Arges	.376	8	14
Nickel	13	Arges	.421	5	14
Nitrites	13	Arges	1.490	1	14
Phenols	13	Arges	.294	4	14
Ammonia NH3	62	Colentina	1.060	1	13.02.04
Nitrites	62	Colentina	1.130	1	13.02.04
Ammonia NH3	44	Colentina	3.470	6	13.02.03
COD-mn	44	Colentina	15.100	2	13.02.03
Nitrates NO3	44	Colentina	11.760	1	13.02.03
Ammonia NH3	36	Colentina	3.230	9	13.02.02
COD-mn	36	Colentina	15.800	8	13.02.02
Nitrates NO3	36	Colentina	11.100	1	13.02.02
Phenols	36	Colentina	.027	9	13.02.02
Ammonia NH3	2	Colentina	2.160	7	13.02.01
COD-mn	2	Colentina	16.700	6	13.02.01
Nitrates NO3	2	Colentina	13.700	2	13.02.01
Phenols	2	Colentina	.022	7	13.02.01

PARMETER NAME	km	RIVER NAME	LARGEST VALUE AT SITE	# OF VALUES ABOVE DW STD.	ICIM SITE ID
Iron Fe	85	Dimbovita	.470	1	13.03
Ammonia NH3	15	Dimbovita	15.210	5	13.01
COD-mn	15	Dimbovita	24.160	9	13.01
Chromium - Cr	15	Dimbovita	.091	1	13.01
Cyanide, total (CN)	15	Dimbovita	.047	10	13.01
Lead Pb	15	Dimbovita	.056	1	13.01
Manganese Mn	15	Dimbovita	.468	10	13.01
Nickel	15	Dimbovita	.299	4	13.01
Phenols	15	Dimbovita	.478	6	13.01
Ammonia NH3	93	Dimbovnic	1.800	3	10.02.03
COD-mn	93	Dimbovnic	17.300	5	10.02.03
Iron Fe	93	Dimbovnic	3.700	7	10.02.03
Ammonia NH3	85	Dimbovnic	30.600	9	10.02.02
COD-mn	85	Dimbovnic	32.200	11	10.02.02
Cadmium	85	Dimbovnic	.035	1	10.02.02
Chloride CL	85	Dimbovnic	266.200	1	10.02.02
Copper Cu	85	Dimbovnic	.056	1	10.02.02
Cyanide, total (CN)	85	Dimbovnic	.097	4	10.02.02
Iron Fe	85	Dimbovnic	.983	7	10.02.02
Phenols	85	Dimbovnic	.890	9	10.02.02
Ammonia NH3	4	Dimbovnic	4.870	9	10.02.01
COD-mn	4	Dimbovnic	16.760	10	10.02.01
Chloride CL	4	Dimbovnic	282.430	1	10.02.01
Cyanide, total (CN)	4	Dimbovnic	.143	3	10.02.01
Iron Fe	4	Dimbovnic	.608	7	10.02.01
Manganese Mn	4	Dimbovnic	.474	4	10.02.01
Nitrates NO3	4	Dimbovnic	12.900	1	10.02.01
Nitrites	4	Dimbovnic	3.290	2	10.02.01
Phenols	4	Dimbovnic	.040	9	10.02.01
COD-mn	60	Doamnei	11.700	1	06.04
Iron Fe	13	Doamnei	.313	1	06.03
Ammonia NH3	86	Neajlov	5.810	4	10.04
Iron Fe	86	Neajlov	.420	3	10.04
Ammonia NH3	54	Neajlov	2.590	3	10.03
COD-mn	54	Neajlov	17.060	7	10.03
Chloride CL	54	Neajlov	8666.700	10	10.03
Iron Fe	54	Neajlov	.380	2	10.03
Manganese Mn	54	Neajlov	.542	4	10.03
Nitrates NO3	54	Neajlov	17.160	2	10.03
Nitrites	54	Neajlov	1.020	1	10.03
Phenols	54	Neajlov	.005	3	10.03
Ammonia NH3	20	Neajlov	2.390	5	10.01
COD-mn	20	Neajlov	16.000	9	10.01
Chloride CL	20	Neajlov	498.703	9	10.01
Cyanide, total (CN)	20	Neajlov	.067	3	10.01
Iron Fe	20	Neajlov	.745	6	10.01
Manganese Mn	20	Neajlov	.478	3	10.01

PARMETER NAME	km	RIVER NAME	LARGEST VALUE AT SITE	# OF VALUES ABOVE DW STD.	ICIM SITE ID
Nitrates NO3	20	Neajlov	14.790	2	10.01
Nitrites	20	Neajlov	3.490	4	10.01
Phenols	20	Neajlov	.030	7	10.01
Chloride CL	62	Sabar (Rastoaca)	547.070	5	11.02
Iron Fe	62	Sabar (Rastoaca)	.341	2	11.02
Manganese Mn	62	Sabar (Rastoaca)	.594	3	11.02
Phenols	62	Sabar (Rastoaca)	.040	1	11.02
Ammonia NH3	24	Sabar (Rastoaca)	17.200	11	11.01
COD-mn	24	Sabar (Rastoaca)	36.300	10	11.01
Nitrates NO3	24	Sabar (Rastoaca)	16.490	3	11.01
Nitrites	24	Sabar (Rastoaca)	1.725	2	11.01
Phenols	24	Sabar (Rastoaca)	.087	9	11.01
COD-mn	4	Tirgului	11.400	1	06.02.01
Iron Fe	4	Tirgului	.313	1	06.02.01
COD-mn	42	Vilsan	10.900	1	05.02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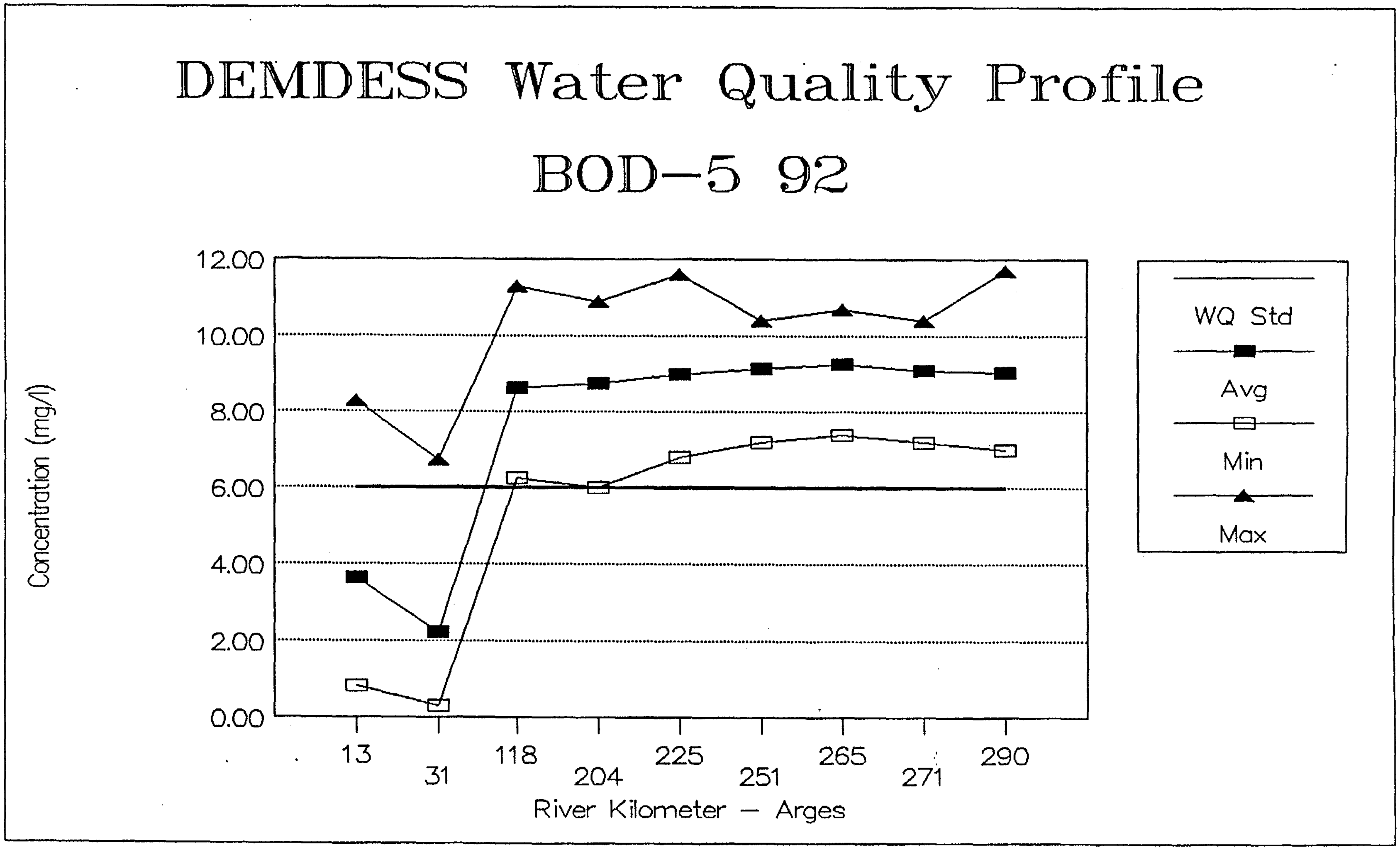
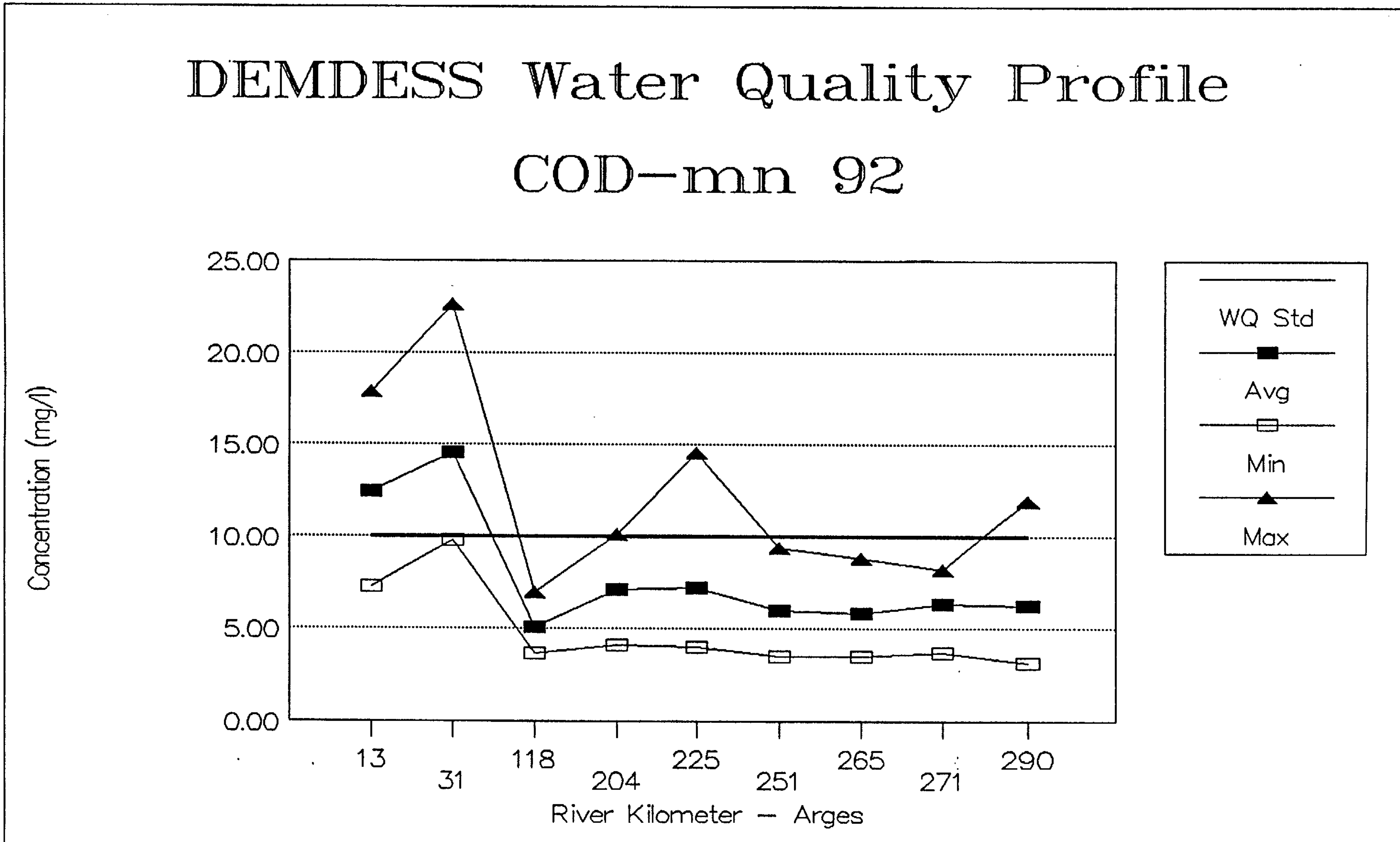
Ammonia NH3 92
Concentration (mg/l)
12.00
10.00
8.00
6.00
4.00
2.00
0.00
13
31
118
204
225
251
265
271
290
River Kilometer — Arges
WQ Std
Avg
Min
Max



DEMDESS Water Quality Profile
BOD-5 92
12.00
10.00
8.00
6.00
4.00
2.00
0.00
Concentration (mg/l)
13
31
118
204
225
251
265
271
290
River Kilometer — Arges
WQ Std
Avg
Min
Max

141

169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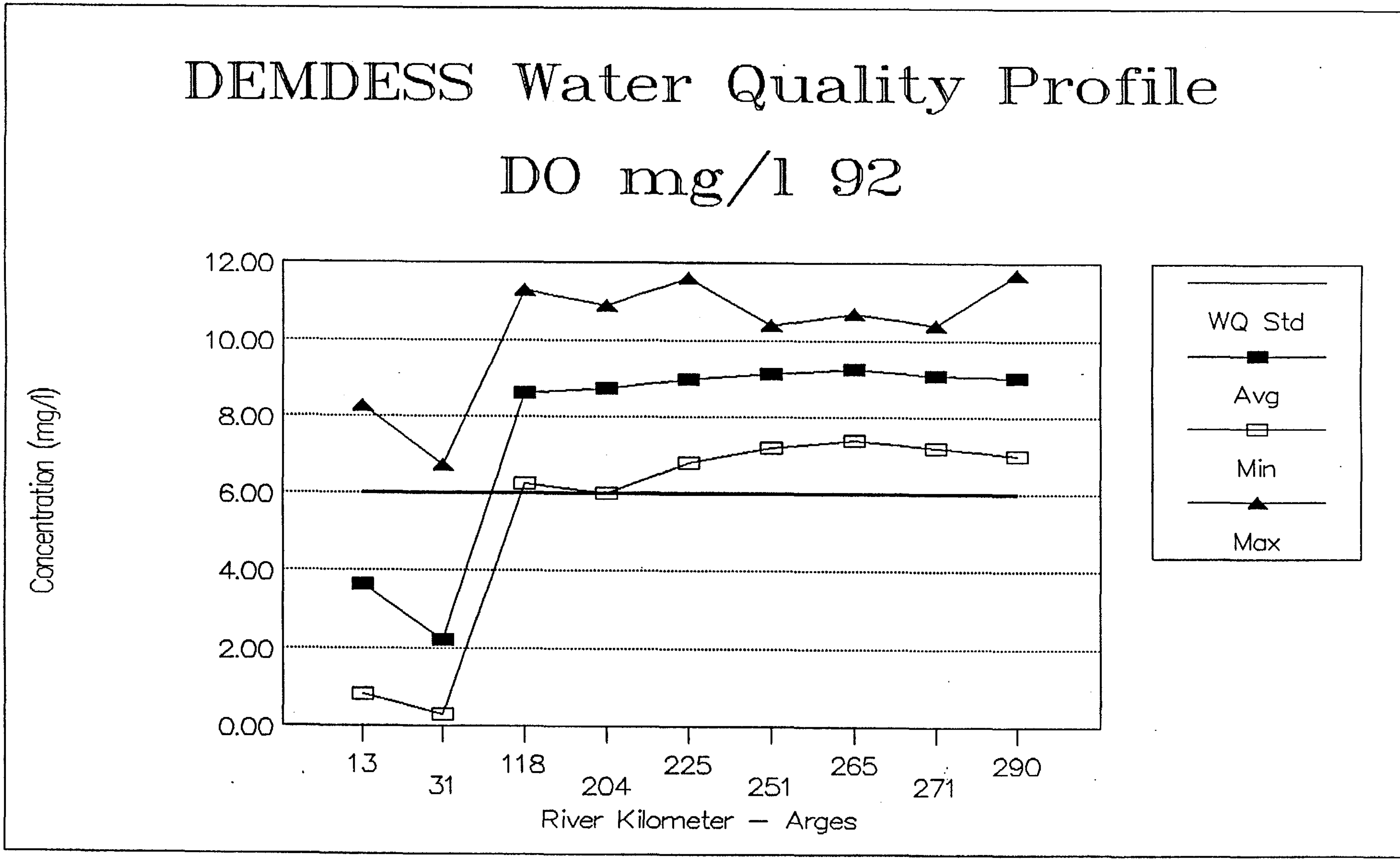
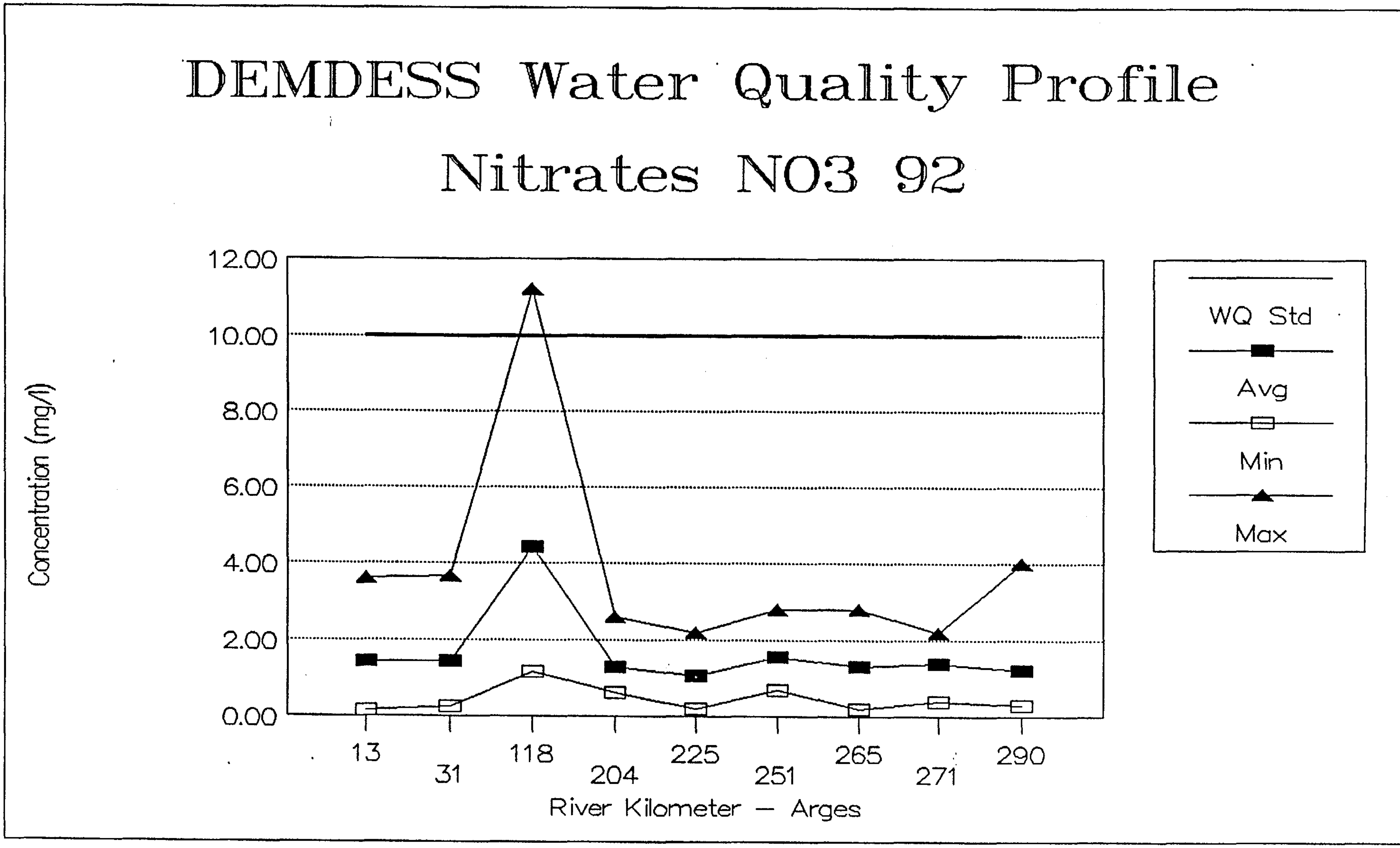
COD-mn 92
Concentration (mg/l)
25.00
20.00
15.00
10.00
5.00
0.00
13
31
118
204
225
251
265
271
290
River Kilometer — Arges
WQ Std
Avg
Min
Max

143

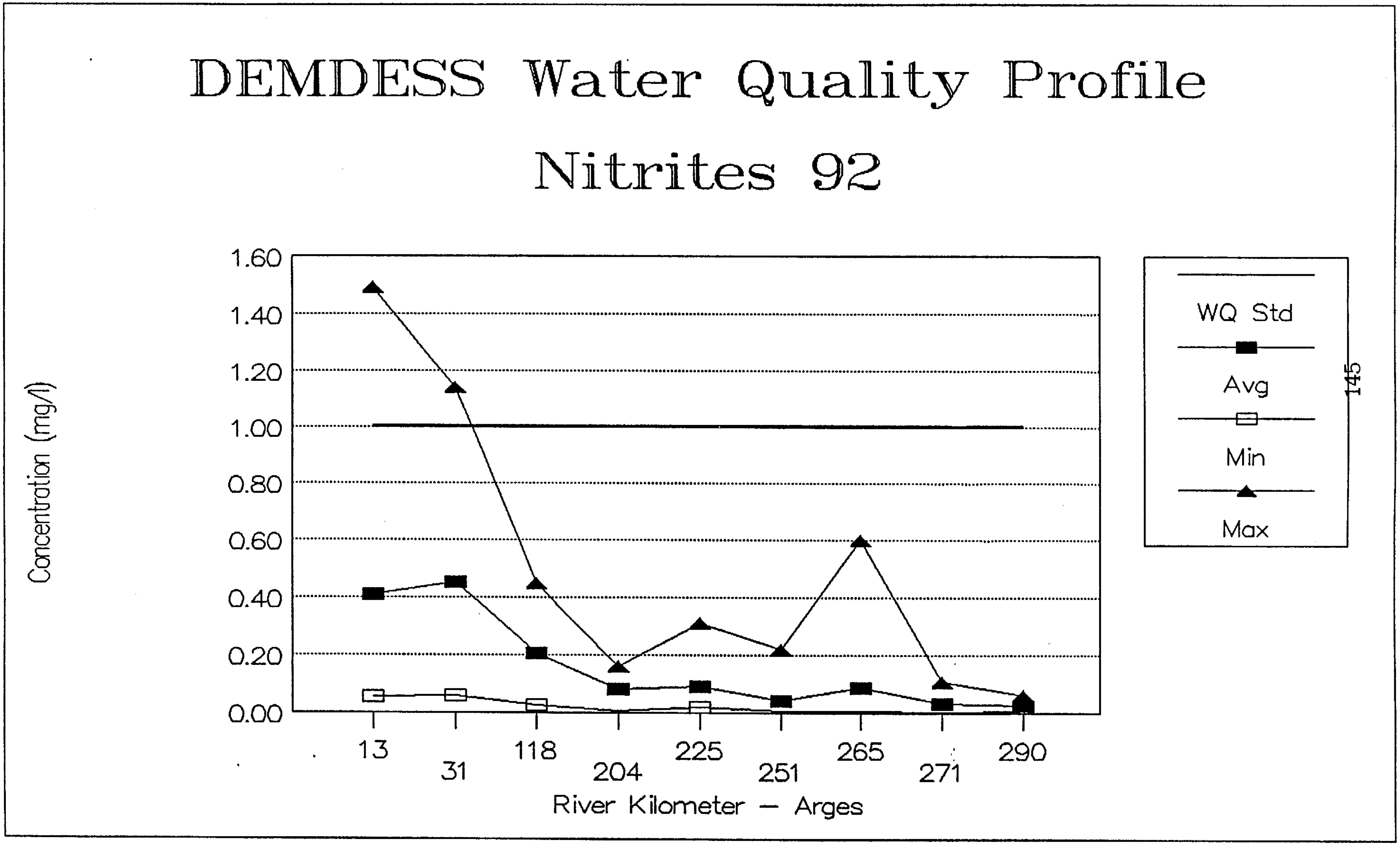
171



DEMDESS Water Quality Profile
DO mg/l 92
12.00
10.00
8.00
6.00
4.00
2.00
0.00
Concentration (mg/l)
13
31
118
204
225
251
265
271
290
River Kilometer — Arges
WQ Std
Avg
Min
Max


DEMDESS Water Quality Profile
Nitrates NO3 92
Concentration (mg/l)
12.00
10.00
8.00
6.00
4.00
2.00
0.00
13
31
118
204
225
251
265
271
290
River Kilometer — Arges
WQ Std
Avg
Min
Max

173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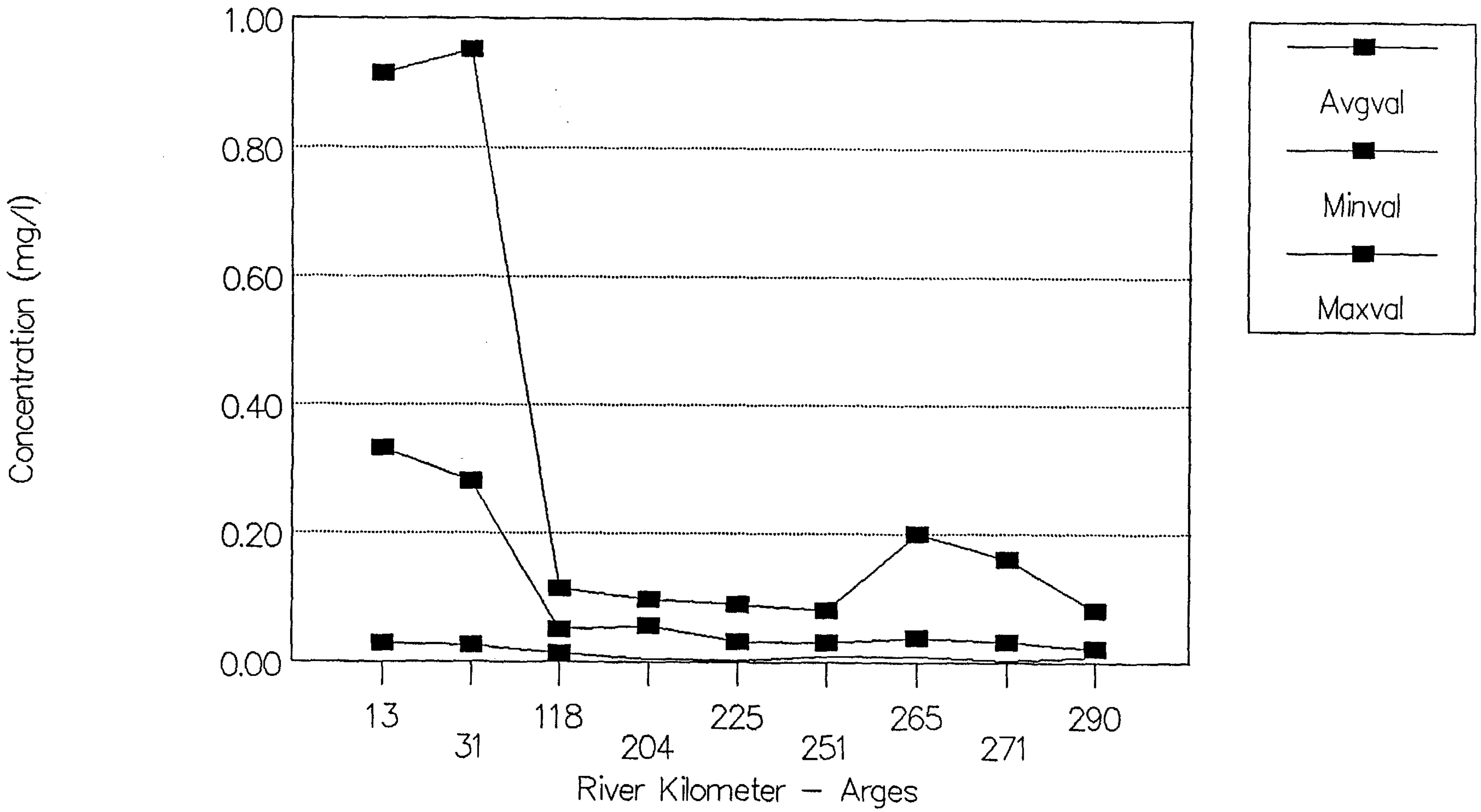
Nitrites 92
Concentration (mg/l)
1.60
1.40
1.20
1.00
0.80
0.60
0.40
0.20
0.00
13
31
118
204
225
251
265
271
290
River Kilometer — Arges
WQ Std
Avg
Min
Max
145

DEMDESS Water Quality Profile

Phosphates 92



APPENDIX B

EMISSION IN THE ARGES BASIN IN 1992

175

TABLE 1
CUMULATIVE LOAD OF PHOSPHATE AT km 0

DISCHARGER I.D. No.	DISCHARGER NAME	DESCRIPTION	DISTANCE FROM km 0 (km)	PHOSPHATE LOAD (kg/day)	% OF TOTAL LOAD	DISCHARGE FLOW (cmd)	DISCHARGE PHOSPHATE CONCENTRATION (mg/L)
BUCHAREST	BUCHAREST WWTP	Municipal WWTP	58	615.6	72.1	1,710,000	0.36
GAESTI	GAESTI WWTP	Municipal WWTP		55.1	6.5	6,480	8.50
11_1	RA REGOCOM	Municipal WWTP Pitesti	224	51.1	6.0	155,945	0.33
32_1	SC AUTOMOBILE DACIA SA	Metal Construction – Small & Machinery	237	30.6	3.6	18,592	1.64
37_1	RA EDILUL	Municipal WWTP Cimpulung	275	23.9	2.8	22,318	1.07
33_1	RA REGOM	Municipal WWTP Colibasi	238	18.5	2.2	15,427	1.20
4_1	RA "GOSARG"	Municipal WWTP Curtea de Arges	266	15.5	1.8	22,027	0.70
20_1	SC ARPECHIM SA	Oil Refining	203	12.2	1.4	47,721	0.26
20_3	SC ARPECHIM SA	Oil Refining	222	6.1	0.7	28,079	0.22
64_1	FERMA PORCI BRADU	Animal Farms	204	4.3	0.5	296	14.60
65_1	ROMSUIN TEST OARJA	Animal Farms	197	4.0	0.5	395	10.20
13_3	SC ROLAST SA	Chemical Industry	232	2.5	0.3	5,162	0.48
56_1	SGCL TOPOLOVENI	Municipal WWTP	210	2.2	0.3	1,907	1.18
12_1	SGCL BASCOV	Municipal WWTP	235	1.6	0.2	690	2.28
52_1	SEPPL STILPENI	Other – Not Classified	253	1.4	0.2	395	3.63
62_1	FERMA PORCI CIUPA	Animal Farms	181	1.2	0.1	99	12.65
54_1	SC CIMUS SA	Other – Not Classified	285	0.9	0.1	778	1.16
58_1	SC VALAHIA	Miscellaneous Food and Beverages	210	0.7	0.1	1,216	0.59
34_1	ICN COLIBASI	Other – Not Classified	230	0.7	0.1	811	0.84
10_1	GRUP INDUSTRIAL PETROL	Petroleum and Gas Extraction	251	0.5	0.1	855	0.54
28_1	UM BASCOV	Other – Not Classified	235	0.4	0.1	121	3.66
38_2	SC ARO SA	Metal Construction – Small & Machinery	284	0.4	0.0	1,216	0.34
25_1	STATIUNEA BRADETU	Other – Not Classified	288	0.4	0.0	263	1.50
18_1	CET GAVANA	Energy Production	232	0.4	0.0	915	0.39
35_1	SGCL MARACINENI	Municipal WWTP	231	0.3	0.0	427	0.73
8_1	SC BAICULESTI	Miscellaneous Food and Beverages	259	0.3	0.0	726	0.36
16_1	TRUST POMICOL	Other – Not Classified	232	0.2	0.0	203	1.23
42_1	MINA JUGUR	Coal Mining	274	0.2	0.0	230	1.06
19_1	HIDROCONSTRUCTIA ARGES	Other – Not Classified	230	0.2	0.0	427	0.53
43_1	MINA GODENI	Coal Mining	272	0.2	0.0	181	1.17
13_2	SC ROLAST SA	Chemical Industry	235	0.2	0.0	1,512	0.13
14_2	SC ROTAN SA	Chemical Industry	234	0.2	0.0	597	0.32
41_1	MINA POENARI	Coal Mining	274	0.2	0.0	181	0.90
44_1	MINA COTESTI	Coal Mining	270	0.2	0.0	181	0.85
59_1	SPITAL CALINESTI	Other – Not Classified	241	0.1	0.0	52	2.63
45_1	MINA PESCAREASA	Coal Mining	272	0.1	0.0	296	0.41
39_2	SC GRULEN SA	Chemical Industry	280	0.1	0.0	1,660	0.07
26_1	UM VALEA URSULUI	Other – Not Classified	242	0.1	0.0	52	2.10
2_1	COLONIA CAPATINENI	Energy Production	292	0.1	0.0	60	1.64
36_1	SC AGROMEC SA	Other – Not Classified	235	0.1	0.0	66	1.18
22_1	COMPLEX VINIFICATIE	Miscellaneous Food and Beverages	218	0.1	0.0	726	0.09
1_1	CABANA CUMPANA	Other – Not Classified	306	0.1	0.0	66	0.98
48_1	MINA ANINOASA	Coal Mining	272	0.1	0.0	99	0.63
79_1	FILATURA MUSCELEANCA SC	Other – Not Classified	203	0.1	0.0	263	0.21
46_1	MINA BEREVOESTI	Coal Mining	273	0.0	0.0	132	0.36
23_1	SPITAL VALEA IASULUI	Other – Not Classified	275	0.0	0.0	66	0.49
47_1	MINA SLANIC	Coal Mining	272	0.0	0.0	132	0.19
3_1	MOTEL CERBURENI	Other – Not Classified	276	0.0	0.0	33	0.61
29_1	BAT BASCOV	Petroleum and Gas Extraction	235	0.0	0.0	66	0.24
			Total Loading =	853.3	kg/day		

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TABLE 2
CUMULATIVE LOAD OF PHOSPHATE AT km 111

DISCHARGER I.D. No.	DISCHARGER NAME	DESCRIPTION	DISTANCE FROM km 111 (km)	PHOSPHATE LOAD (kg/day)	% OF TOTAL LOAD	DISCHARGE FLOW (cmd)	DISCHARGE PHOSPHATE CONCENTRATION (mg/L)
11_1	RA REGOCOM	Municipal WWTP	113	51.1	31.8	155,945	0.33
32_1	SC AUTOMOBILE DACIA SA	Metal Construction – Small & Machinery	126	30.6	19.0	18,592	1.64
37_1	RA EDILUL	Municipal WWTP	164	23.9	14.8	22,318	1.07
33_1	RA REGOM	Municipal WWTP	127	18.5	11.5	15,427	1.20
4_1	RA "GOSARG"	Municipal WWTP	155	15.5	9.6	22,027	0.70
20_3	SC ARPECHIM SA	Oil Refining	111	6.1	3.8	28,079	0.22
13_3	SC ROLAST SA	Chemical Industry	121	2.5	1.6	5,162	0.48
56_1	SGCL TOPOLOVENI	Municipal WWTP	99	2.2	1.4	1,907	1.18
12_1	SGCL BASCOV	Municipal WWTP	124	1.6	1.0	690	2.26
52_1	SEPPL STILPENI	Other – Not Classified	142	1.4	0.9	395	3.63
54_1	SC CIMUS SA	Other – Not Classified	174	0.9	0.6	778	1.16
58_1	SC VALAHIA	Miscellaneous Food and Beverages	99	0.7	0.4	1,216	0.59
34_1	ICN COLIBASI	Other – Not Classified	119	0.7	0.4	811	0.84
10_1	GRUP INDUSTRIAL PETROL	Petroleum and Gas Extraction	140	0.5	0.3	855	0.54
28_1	UM BASCOV	Other – Not Classified	124	0.4	0.3	121	3.66
38_2	SC ARO SA	Metal Construction – Small & Machinery	173	0.4	0.3	1,216	0.34
25_1	STATIUNEA BRADETU	Other – Not Classified	177	0.4	0.2	263	1.50
18_1	CET GAVANA	Energy Production	121	0.4	0.2	915	0.39
35_1	SGCL MARACINENI	Municipal WWTP	120	0.3	0.2	427	0.73
8_1	SC BAICULESTI	Miscellaneous Food and Beverages	148	0.3	0.2	726	0.36
16_1	TRUST POMICOL	Other – Not Classified	121	0.2	0.2	203	1.23
42_1	MINA JUGUR	Coal Mining	163	0.2	0.2	230	1.06
19_1	HIDROCONSTRUCTIA ARGES	Other – Not Classified	119	0.2	0.1	427	0.53
43_1	MINA GODENI	Coal Mining	161	0.2	0.1	181	1.17
13_2	SC ROLAST SA	Chemical Industry	124	0.2	0.1	1,512	0.13
14_2	SC ROTAN SA	Chemical Industry	123	0.2	0.1	597	0.32
41_1	MINA POENARI	Coal Mining	163	0.2	0.1	181	0.90
44_1	MINA COTESTI	Coal Mining	159	0.2	0.1	181	0.85
59_1	SPITAL CALINESTI	Other – Not Classified	130	0.1	0.1	52	2.63
45_1	MINA PESCAREASA	Coal Mining	161	0.1	0.1	296	0.41
39_2	SC GRULEN SA	Chemical Industry	169	0.1	0.1	1,660	0.07
26_1	UM VALEA URSULUI	Other – Not Classified	131	0.1	0.1	52	2.10
2_1	COLONIA CAPATINENI	Energy Production	181	0.1	0.1	60	1.64
36_1	SC AGROMEC SA	Other – Not Classified	124	0.1	0.0	66	1.18
22_1	COMPLEX VINIFICATIE	Miscellaneous Food and Beverages	107	0.1	0.0	726	0.09
1_1	CABANA CUMPANA	Other – Not Classified	195	0.1	0.0	66	0.98
48_1	MINA ANINOASA	Coal Mining	161	0.1	0.0	99	0.63
46_1	MINA BEREVOESTI	Coal Mining	162	0.0	0.0	132	0.36
23_1	SPITAL VALEA IASULUI	Other – Not Classified	164	0.0	0.0	66	0.49
47_1	MINA SLANIC	Coal Mining	161	0.0	0.0	132	0.19
3_1	MOTEL CERBURENI	Other – Not Classified	165	0.0	0.0	33	0.61
29_1	BAT BASCOV	Petroleum and Gas Extraction	124	0.0	0.0	66	0.24
			Total Loading =	160.7 kg/day			

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TABLE 3
CUMULATIVE LOAD OF PHOSPHATE AT km 240

DISCHARGER I.D. No.	DISCHARGER NAME	DESCRIPTION	DISTANCE FROM km 240 (km)	PHOSPHATE LOAD (kg/day)	% OF TOTAL LOAD	DISCHARGE FLOW (cmd)	DISCHARGE PHOSPHATE CONCENTRATION (mg/L)
4_1	RA "GOSARG"	Municipal WWTP	26	15.5	92.3	22,027	0.70
10_1	GRUP INDUSTRIAL PETROL	Petroleum and Gas Extraction	11	0.5	2.7	855	0.54
25_1	STATIUNEA BRADETU	Other – Not Classified	48	0.4	2.4	263	1.50
6_1	SC BAICULESTI	Miscellaneous Food and Beverages	19	0.3	1.5	726	0.36
2_1	COLONIA CAPATINENI	Energy Production	52	0.1	0.6	60	1.64
1_1	CABANA CUMPANA	Other – Not Classified	66	0.1	0.4	66	0.98
3_1	MOTEL CERBURENI	Other – Not Classified	36	0.0	0.1	33	0.61
			Total Loading =	16.7	kg/day		

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TABLE 4
CUMULATIVE LOAD OF NITRATE AT km 0

DISCHARGER I.D. No.	DISCHARGER NAME	DESCRIPTION	DISTANCE FROM km 0 (km)	NITRATE LOAD (kg/day)	% OF TOTAL LOAD	DISCHARGE FLOW (cmd)	DISCHARGE NITRATE CONCENTRATION (mg/L)
BUCHREST	BUCHREST WWTP	Municipal WWTP	58	3078.0	90.0	1,710,000	1.8
11_1	RA REGOCOM	Municipal WWTP	224	137.2	4.0	155,945	0.9
20_1	SC ARPECHIM SA	Oil Refining	203	50.9	1.5	47,721	1.1
20_3	SC ARPECHIM SA	Oil Refining	222	28.1	0.8	28,079	1.0
32_1	SC AUTOMOBILE DACIA SA	Metal Construction - Small & Machinery	237	26.0	0.8	18,592	1.4
4_1	RA "GOSARG"	Municipal WWTP	266	21.4	0.6	22,027	1.0
37_1	RA EDILUL	Municipal WWTP	275	21.3	0.6	22,318	1.0
13_3	SC ROLAST SA	Chemical Industry	232	17.9	0.5	5,162	3.5
BUFTEA	BUFTEA WWTP	BUFTEA WWTP		9.9	0.3	9,936	1.0
33_1	RA REGOM	Municipal WWTP	238	7.4	0.2	15,427	0.5
38_2	SC ARO SA	Metal Construction - Small & Machinery	264	2.9	0.1	1,216	2.4
34_1	ICN COLIBASI	Other - Not Classified	230	2.3	0.1	811	2.8
56_1	SGCL TOPOLOVENI	Municipal WWTP	210	1.3	0.0	1,907	0.7
39_2	SC GRULEN SA	Chemical Industry	260	1.3	0.0	1,660	0.8
65_1	ROMSUIN TEST OARJA	Animal Farms	197	1.3	0.0	395	3.2
GAESTI	GAESTI WWTP	GAESTI WWTP		1.3	0.0	6,480	0.2
18_1	CET GAVANA	Energy Production	232	1.2	0.0	915	1.4
14_2	SC ROTAN SA	Chemical Industry	234	1.2	0.0	597	2.0
13_2	SC ROLAST SA	Chemical Industry	235	1.1	0.0	1,512	0.7
54_1	SC CIMUS SA	Other - Not Classified	285	1.0	0.0	778	1.3
79_1	FILATURA MUSCELEANCA SC	Other - Not Classified	203	0.9	0.0	263	3.4
22_1	COMPLEX VINIFICATIE	Miscellaneous Food and Beverages	218	0.9	0.0	726	1.2
10_1	GRUP INDUSTRIAL PETROL	Petroleum and Gas Extraction	251	0.7	0.0	855	0.8
58_1	SC VALAHIA	Miscellaneous Food and Beverages	210	0.6	0.0	1,216	0.5
8_1	SC BAICULESTI	Miscellaneous Food and Beverages	259	0.4	0.0	726	0.6
12_1	SGCL BASCOV	Municipal WWTP	235	0.4	0.0	690	0.6
35_1	SGCL MARACINENI	Municipal WWTP	231	0.4	0.0	427	1.0
64_1	FERMA PORCI BRADU	Animal Farms	204	0.4	0.0	296	1.3
19_1	HIDROCONSTRUCTIA ARGES	Other - Not Classified	230	0.3	0.0	427	0.8
48_1	MINA ANINOASA	Coal Mining	272	0.3	0.0	99	2.6
46_1	MINA BEREVOESTI	Coal Mining	273	0.2	0.0	132	1.9
52_1	SEPPL STILPENI	Other - Not Classified	253	0.2	0.0	395	0.5
44_1	MINA COTESTI	Coal Mining	270	0.2	0.0	181	1.1
41_1	MINA POENARI	Coal Mining	274	0.1	0.0	181	0.7
45_1	MINA PESCAREASA	Coal Mining	272	0.1	0.0	296	0.4
16_1	TRUST POMICOL	Other - Not Classified	232	0.1	0.0	203	0.5
25_1	STATIUNEA BRADETU	Other - Not Classified	288	0.1	0.0	263	0.3
29_1	BAT BASCOV	Petroleum and Gas Extraction	235	0.1	0.0	66	1.1
43_1	MINA GODENI	Coal Mining	272	0.1	0.0	181	0.4
42_1	MINA JUGUR	Coal Mining	274	0.1	0.0	230	0.3
47_1	MINA SLANIC	Coal Mining	272	0.1	0.0	132	0.5
62_1	FERMA PORCI CIUPA	Animal Farms	181	0.1	0.0	99	0.6
1_1	CABANA CUMPANA	Other - Not Classified	306	0.1	0.0	66	0.8
3_1	MOTEL CERBURENI	Other - Not Classified	276	0.1	0.0	33	1.6
23_1	SPITAL VALEA IASULUI	Other - Not Classified	275	0.0	0.0	66	0.7
2_1	COLONIA CAPATINENI	Energy Production	292	0.0	0.0	60	0.7
36_1	SC AGROMEC SA	Other - Not Classified	235	0.0	0.0	66	0.6
26_1	UM VALEA URSULUI	Other - Not Classified	242	0.0	0.0	52	0.7
28_1	UM BASCOV	Other - Not Classified	235	0.0	0.0	121	0.3
49_1	MINA BOTENI	Coal Mining	275	0.0	0.0	66	0.3
59_1	SPITAL CALINESTI	Other - Not Classified	241	0.0	0.0	52	0.3
			Total Load =	3420.3	kg/day		

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TABLE 5
CUMULATIVE LOAD OF NITRATE AT km 111

DISCHARGER I.D. No.	DISCHARGER NAME	DESCRIPTION	DISTANCE FROM km 111 (km)	NITRATE LOAD (kg/day)	% OF TOTAL LOAD	DISCHARGE FLOW (cmd)	DISCHARGE NITRATE CONCENTRATION (mg/L)
11_1	RA REGOCOM	Municipal WWTP	113	137.2	46.6	155,945	0.9
20_3	SC ARPECHIM SA	Oil Refining	111	28.1	9.5	28,079	1.0
32_1	SC AUTOMOBILE DACIA SA	Metal Construction - Small & Machinery	126	26.0	8.8	18,592	1.4
4_1	RA "GOSARG"	Municipal WWTP	155	21.4	7.3	22,027	1.0
37_1	RA EDILUL	Municipal WWTP	164	21.3	7.2	22,318	1.0
13_3	SC ROLAST SA	Chemical Industry	121	17.9	6.1	5,162	3.5
33_1	RA REGOM	Municipal WWTP	127	7.4	2.5	15,427	0.5
38_2	SC ARO SA	Metal Construction - Small & Machinery	173	2.9	1.0	1,216	2.4
34_1	ICN COLIBASI	Other - Not Classified	119	2.3	0.8	811	2.8
56_1	SGCL TOPOLOVENI	Municipal WWTP	99	1.3	0.5	1,907	0.7
39_2	SC GRULEN SA	Chemical Industry	169	1.3	0.5	1,660	0.8
18_1	CET GAVANA	Energy Production	121	1.2	0.4	915	1.4
14_2	SC ROTAN SA	Chemical Industry	123	1.2	0.4	597	2.0
13_2	SC ROLAST SA	Chemical Industry	124	1.1	0.4	1,512	0.7
54_1	SC CIMUS SA	Other - Not Classified	174	1.0	0.4	778	1.3
22_1	COMPLEX VINIFICATIE	Miscellaneous Food and Beverages	107	0.9	0.3	726	1.2
10_1	GRUP INDUSTRIAL PETROL	Petroleum and Gas Extraction	140	0.7	0.2	855	0.8
58_1	SC VALAHIA	Miscellaneous Food and Beverages	99	0.6	0.2	1,216	0.5
8_1	SC BAICULESTI	Miscellaneous Food and Beverages	148	0.4	0.1	726	0.6
12_1	SGCL BASCOV	Municipal WWTP	124	0.4	0.1	690	0.6
35_1	SGCL MARACINENI	Municipal WWTP	120	0.4	0.1	427	1.0
19_1	HIDROCONSTRUCTIA ARGES	Other - Not Classified	119	0.3	0.1	427	0.8
48_1	MINA ANINOASA	Coal Mining	161	0.3	0.1	99	2.6
46_1	MINA BEREVOESTI	Coal Mining	162	0.2	0.1	132	1.9
52_1	SEPPL STILPENI	Other - Not Classified	142	0.2	0.1	395	0.5
44_1	MINA COTESTI	Coal Mining	159	0.2	0.1	181	1.1
41_1	MINA POENARI	Coal Mining	163	0.1	0.0	181	0.7
45_1	MINA PESCAREASA	Coal Mining	161	0.1	0.0	296	0.4
16_1	TRUST POMICOL	Other - Not Classified	121	0.1	0.0	203	0.5
25_1	STATIUNEA BRADETU	Other - Not Classified	177	0.1	0.0	263	0.3
29_1	BAT BASCOV	Petroleum and Gas Extraction	124	0.1	0.0	66	1.1
43_1	MINA GODENI	Coal Mining	161	0.1	0.0	181	0.4
42_1	MINA JUGUR	Coal Mining	163	0.1	0.0	230	0.3
47_1	MINA SLANIC	Coal Mining	161	0.1	0.0	132	0.5
1_1	CABANA CUMPANA	Other - Not Classified	195	0.1	0.0	66	0.8
3_1	MOTEL CERBURENI	Other - Not Classified	165	0.1	0.0	33	1.6
23_1	SPITAL VALEA IASULUI	Other - Not Classified	164	0.0	0.0	66	0.7
2_1	COLONIA CAPATINENI	Energy Production	181	0.0	0.0	60	0.7
36_1	SC AGROMEC SA	Other - Not Classified	124	0.0	0.0	66	0.6
26_1	UM VALEA URSULUI	Other - Not Classified	131	0.0	0.0	52	0.7
28_1	UM BASCOV	Other - Not Classified	124	0.0	0.0	121	0.3
49_1	MINA BOTENI	Coal Mining	164	0.0	0.0	66	0.3
59_1	SPITAL CALINESTI	Other - Not Classified	130	0.0	0.0	52	0.3
			Total Loading =	277.5	kg/day		

TABLE 6
CUMULATIVE LOAD OF NITRATE AT km 240

DISCHARGER I.D. No.	DISCHARGER NAME	DESCRIPTION	DISTANCE FROM km 240 (km)	NITRATE LOAD (kg/day)	% OF TOTAL LOAD	DISCHARGE FLOW (cmd)	DISCHARGE NITRATE CONCENTRATION (mg/L)
4_1	RA "GOSARG"	Municipal WWTP	155	21.4	94.1	22,027	1.0
10_1	GRUP INDUSTRIAL PETROL	Petroleum and Gas Extraction	140	0.7	3.0	855	0.8
8_1	SC BAICULESTI	Miscellaneous Food and Beverages	148	0.4	1.9	726	0.6
25_1	STATIUNEA BRADETU	Other – Not Classified	177	0.1	0.4	263	0.3
1_1	CABANA CUMPANA	Other – Not Classified	195	0.1	0.2	66	0.8
3_1	MOTEL CERBURENI	Other – Not Classified	165	0.1	0.2	33	1.6
2_1	COLONIA CAPATINENI	Energy Production	181	0.0	0.2	60	0.7
			Total Loading =	22.8	kg/day		

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TABLE 7
CUMULATIVE LOAD OF AMMONIA AT km 0

DISCHARGER I.D. No.	DISCHARGER NAME	DESCRIPTION	DISTANCE FROM km 0 (km)	AMMONIA LOAD (kg/day)	% OF TOTAL LOAD	DISCHARGE FLOW (cmd)	DISCHARGE AMMONIA CONCENTRATION (mg/L)
BUCHREST	BUCHREST WWTP	Municipal WWTP	58	6498.0	72.0	1,710,000	3.8
20_1	SC ARPECHIM SA	Oil Refining	203	1035.5	11.5	47,721	21.7
11_1	RA REGOCOM	Municipal WWTP	224	736.1	8.2	155,945	4.7
37_1	RA EDILUL	Municipal WWTP	275	141.8	1.6	22,318	6.4
4_1	RA "GOSARG"	Municipal WWTP	266	135.9	1.5	22,027	6.2
64_1	FERMA PORCI BRADU	Animal Farms	204	88.8	1.0	296	300.0
32_1	SC AUTOMOBILE DACIA SA	Metal Construction – Small & Machinery	237	75.0	0.8	18,592	4.0
65_1	ROMSUIN TEST OARJA	Animal Farms	197	61.5	0.7	395	156.0
33_1	RA REGOM	Municipal WWTP	238	60.2	0.7	15,427	3.9
BUFTEA	BUFTEA WWTP	Municipal WWTP		51.7	0.6	9,936	5.2
GAESTI	GAESTI WWTP	Municipal WWTP		30.5	0.3	6,480	4.7
56_1	SGCL TOPOLOVENI	Municipal WWTP	210	16.9	0.2	1,907	8.9
20_3	SC ARPECHIM SA	Oil Refining	222	12.2	0.1	28,079	0.4
54_1	SC CIMUS SA	Other – Not Classified	285	8.3	0.1	778	10.6
62_1	FERMA PORCI CIUPA	Animal Farms	181	6.9	0.1	99	70.2
58_1	SC VALAHIA	Miscellaneous Food and Beverages	210	6.9	0.1	1,216	5.7
52_1	SEPPL STILPENI	Other – Not Classified	253	5.8	0.1	395	14.6
12_1	SGCL BASCOV	Municipal WWTP	235	5.4	0.1	690	7.8
13_3	SC ROLAST SA	Chemical Industry	232	4.5	0.0	5,162	0.9
10_1	GRUP INDUSTRIAL PETROL	Petroleum and Gas Extraction	251	4.3	0.0	855	5.0
19_1	HIDROCONSTRUCTIA ARGES	Other – Not Classified	230	3.5	0.0	427	8.3
25_1	STATIUNEA BRADETU	Other – Not Classified	288	3.1	0.0	263	11.7
28_1	UM BASCOV	Other – Not Classified	235	2.7	0.0	121	22.8
16_1	TRUST POMICOL	Other – Not Classified	232	2.5	0.0	203	12.5
34_1	ICN COLIBASI	Other – Not Classified	230	2.3	0.0	811	2.8
44_1	MINA COTESTI	Coal Mining	270	2.1	0.0	181	11.9
42_1	MINA JUGUR	Coal Mining	274	2.1	0.0	230	9.1
35_1	SGCL MARACINENI	Municipal WWTP	231	2.0	0.0	427	4.6
41_1	MINA POENARI	Coal Mining	274	1.6	0.0	181	8.9
1_1	CABANA CUMPANA	Other – Not Classified	306	1.6	0.0	66	24.0
43_1	MINA GODENI	Coal Mining	272	1.5	0.0	181	8.5
26_1	UM VALEA URSULUI	Other – Not Classified	242	1.4	0.0	52	26.1
18_1	CET GAVANA	Energy Production	232	1.3	0.0	915	1.4
38_2	SC ARO SA	Metal Construction – Small & Machinery	284	1.1	0.0	1,216	0.9
8_1	SC BAICULESTI	Miscellaneous Food and Beverages	259	0.8	0.0	726	1.1
47_1	MINA SLANIC	Coal Mining	272	0.7	0.0	132	5.0
45_1	MINA PESCAREASA	Coal Mining	272	0.5	0.0	296	1.8
49_1	MINA BOTENI	Coal Mining	275	0.5	0.0	66	7.2
59_1	SPITAL CALINESTI	Other – Not Classified	241	0.4	0.0	52	8.4
13_2	SC ROLAST SA	Chemical Industry	235	0.4	0.0	1,512	0.3
22_1	COMPLEX VINIFICATIE	Miscellaneous Food and Beverages	218	0.4	0.0	726	0.5
46_1	MINA BEREVOESTI	Coal Mining	273	0.4	0.0	132	2.7
36_1	SC AGROMEC SA	Other – Not Classified	235	0.3	0.0	66	5.1
14_2	SC ROTAN SA	Chemical Industry	234	0.3	0.0	597	0.5
48_1	MINA ANINOASA	Coal Mining	272	0.2	0.0	99	2.4
2_1	COLONIA CAPATINENI	Energy Production	292	0.2	0.0	60	3.4
23_1	SPITAL VALEA IASULUI	Other – Not Classified	275	0.1	0.0	66	1.9
79_1	FILATURA MUSCELEANCA SC	Other – Not Classified	203	0.1	0.0	263	0.4
29_1	BAT BASCOV	Petroleum and Gas Extraction	235	0.0	0.0	66	0.6
3_1	MOTEL CERBURENI	Other – Not Classified	276	0.0	0.0	33	0.5
39_2	SC GRULEN SA	Chemical Industry	280	0.0	0.0	1,660	0.0
			Total Loading =	9020.2	kg/day		

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TABLE 8
CUMULATIVE LOAD OF AMMONIA AT km 111

DISCHARGER I.D. No.	DISCHARGER NAME	DESCRIPTION	DISTANCE FROM km 111 (km)	AMMONIA LOAD (kg/day)	% OF TOTAL LOAD	DISCHARGE FLOW (cmd)	DISCHARGE AMMONIA CONCENTRATION (mg/L)
11_1	RA REGOCOM	Municipal WWTP	113	736.1	59.0	155,945	4.7
37_1	RA EDILUL	Municipal WWTP	164	141.8	11.4	22,318	6.4
4_1	RA "GOSARG"	Municipal WWTP	155	135.9	10.9	22,027	6.2
32_1	SC AUTOMOBILE DACIA SA	Metal Construction – Small & Machinery	126	75.0	6.0	18,592	4.0
33_1	RA REGOM	Municipal WWTP	127	60.2	4.8	15,427	3.9
56_1	SGCL TOPOLOVENI	Municipal WWTP	99	16.9	1.4	1,907	8.9
20_3	SC ARPECHIM SA	Oil Refining	111	12.2	1.0	28,079	0.4
54_1	SC CIMUS SA	Other – Not Classified	174	8.3	0.7	778	10.6
58_1	SC VALAHIA	Miscellaneous Food and Beverages	99	6.9	0.6	1,216	5.7
52_1	SEPPL STILPENI	Other – Not Classified	142	5.8	0.5	395	14.6
12_1	SGCL BASCOV	Municipal WWTP	124	5.4	0.4	690	7.8
13_3	SC ROLAST SA	Chemical Industry	121	4.5	0.4	5,162	0.9
10_1	GRUP INDUSTRIAL PETROL	Petroleum and Gas Extraction	140	4.3	0.3	855	5.0
19_1	HIDROCONSTRUCTIA ARGES	Other – Not Classified	119	3.5	0.3	427	8.3
25_1	STATIUNEA BRADETU	Other – Not Classified	177	3.1	0.2	263	11.7
28_1	UM BASCOV	Other – Not Classified	124	2.7	0.2	121	22.8
16_1	TRUST POMICOL	Other – Not Classified	121	2.5	0.2	203	12.5
34_1	ICN COLIBASI	Other – Not Classified	119	2.3	0.2	811	2.8
44_1	MINA COTESTI	Coal Mining	159	2.1	0.2	181	11.9
42_1	MINA JUGUR	Coal Mining	163	2.1	0.2	230	9.1
35_1	SGCL MARACINENI	Municipal WWTP	120	2.0	0.2	427	4.6
41_1	MINA POENARI	Coal Mining	163	1.6	0.1	181	8.9
1_1	CABANA CUMPANA	Other – Not Classified	195	1.6	0.1	66	24.0
43_1	MINA GODENI	Coal Mining	161	1.5	0.1	181	8.5
26_1	UM VALEA URSULUI	Other – Not Classified	131	1.4	0.1	52	26.1
18_1	CET GAVANA	Energy Production	121	1.3	0.1	915	1.4
38_2	SC ARO SA	Metal Construction – Small & Machinery	173	1.1	0.1	1,216	0.9
8_1	SC BAICULESTI	Miscellaneous Food and Beverages	148	0.8	0.1	726	1.1
47_1	MINA SLANIC	Coal Mining	161	0.7	0.1	132	5.0
45_1	MINA PESCAREASA	Coal Mining	161	0.5	0.0	296	1.8
49_1	MINA BOTENI	Coal Mining	164	0.5	0.0	66	7.2
59_1	SPITAL CALINESTI	Other – Not Classified	130	0.4	0.0	52	8.4
13_2	SC ROLAST SA	Chemical Industry	124	0.4	0.0	1,512	0.3
22_1	COMPLEX VINIFICATIE	Miscellaneous Food and Beverages	107	0.4	0.0	726	0.5
46_1	MINA BEREVOESTI	Coal Mining	162	0.4	0.0	132	2.7
36_1	SC AGROMEC SA	Other – Not Classified	124	0.3	0.0	66	5.1
14_2	SC ROTAN SA	Chemical Industry	123	0.3	0.0	597	0.5
48_1	MINA ANINOASA	Coal Mining	161	0.2	0.0	99	2.4
2_1	COLONIA CAPATINENI	Energy Production	181	0.2	0.0	60	3.4
23_1	SPITAL VALEA IASULUI	Other – Not Classified	164	0.1	0.0	66	1.9
29_1	BAT BASCOV	Petroleum and Gas Extraction	124	0.0	0.0	66	0.6
3_1	MOTEL CERBURENI	Other – Not Classified	165	0.0	0.0	33	0.5
39_2	SC GRULEN SA	Chemical Industry	169	0.0	0.0	1,660	0.0
			Total Loading =	1247.2	kg/day		

TABLE 9
CUMULATIVE LOAD OF AMMONIA AT km 240

DISCHARGER I.D. No.	DISCHARGER NAME	DESCRIPTION	DISTANCE FROM km 240 (km)	AMMONIA LOAD (kg/day)	% OF TOTAL LOAD	DISCHARGE FLOW (cmd)	DISCHARGE AMMONIA CONCENTRATION (mg/L)
4_1	RA "GOSARG"	Municipal WWTP	155	135.9	93.7	22,027	6.2
10_1	GRUP INDUSTRIAL PETROL	Petroleum and Gas Extraction	140	4.3	2.9	855	5.0
25_1	STATIUNEA BRADETU	Other – Not Classified	177	3.1	2.1	263	11.7
1_1	CABANA CUMPANA	Other – Not Classified	195	1.6	1.1	66	24.0
2_1	COLONIA CAPATINENI	Energy Production	181	0.2	0.1	60	3.4
3_1	MOTEL CERBURENI	Other – Not Classified	165	0.0	0.0	33	0.5
			Total Loading =	145.1	kg/day		

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TABLE 10
CUMULATIVE LOAD OF BOD5 AT km 0

DISCHARGER I.D. No.	DISCHARGER NAME	DESCRIPTION	DISTANCE FROM km 0 (km)	BOD5 LOAD (kg/day)	% OF TOTAL LOAD	DISCHARGE FLOW (cmd)	DISCHARGE BOD5 CONCENTRATION (mg/L)
BUCHAREST	BUCHAREST WASTEWATER	Municipal WWTP	58	342000.0	94.4	1,710,000	200.0
11_1	RA REGOCOM	Municipal WWTP	224	8826.5	2.4	155,945	56.6
4_1	RA "GOSARG"	Municipal WWTP	266	1746.5	0.5	22,027	79.3
20_1	SC ARPECHIM SA	Oil Refining	203	1558.9	0.4	47,721	32.7
BUFTEA	BUFTEA WWTP	Municipal WWTP		1490.4	0.4	9,936	150.0
37_1	RA EDILUL	Municipal WWTP	275	1259.7	0.3	22,318	56.4
32_1	SC AUTOMOBILE DACIA SA	Metal Construction – Small & Machinery	237	1146.5	0.3	18,592	61.7
20_3	SC ARPECHIM SA	Oil Refining	222	1029.6	0.3	28,079	36.7
GAESTI	GAESTI WWTP	Municipal WWTP		874.8	0.2	6,480	135.0
33_1	RA REGOM	Municipal WWTP	238	771.4	0.2	15,427	50.0
65_1	ROMSUIN TEST OARJA	Animal Farms	197	323.5	0.1	395	820.0
58_1	SC VALAHIA	Miscellaneous Food and Beverages	210	202.7	0.1	1,216	166.7
56_1	SGCL TOPOLOVENI	Municipal WWTP	210	150.2	0.0	1,907	78.8
13_3	SC ROLAST SA	Chemical Industry	232	135.9	0.0	5,162	26.3
64_1	FERMA PORCI BRADU	Animal Farms	204	90.0	0.0	296	304.0
39_2	SC GRULEN SA	Chemical Industry	280	83.0	0.0	1,660	50.0
10_1	GRUP INDUSTRIAL PETROL	Petroleum and Gas Extraction	251	74.8	0.0	855	87.5
22_1	COMPLEX VINIFICATIE	Miscellaneous Food and Beverages	218	72.6	0.0	726	100.0
44_1	MINA COTESTI	Coal Mining	270	53.8	0.0	181	297.5
34_1	ICN COLIBASI	Other – Not Classified	230	51.6	0.0	811	63.6
8_1	SC BAICULESTI	Miscellaneous Food and Beverages	259	47.7	0.0	726	65.7
12_1	SGCL BASCOV	Municipal WWTP	235	43.8	0.0	690	63.5
18_1	CET GAVANA	Energy Production	232	42.6	0.0	915	46.5
19_1	HIDROCONSTRUCTIA ARGES	Other – Not Classified	230	36.3	0.0	427	85.0
54_1	SC CIMUS SA	Other – Not Classified	285	34.8	0.0	778	44.7
35_1	SGCL MARACINENI	Municipal WWTP	231	33.7	0.0	427	78.8
14_2	SC ROTAN SA	Chemical Industry	234	29.9	0.0	597	50.0
13_2	SC ROLAST SA	Chemical Industry	235	28.0	0.0	1,512	18.5
52_1	SEPPL STILPENI	Other – Not Classified	253	22.4	0.0	395	56.7
25_1	STATIUNEA BRADETU	Other – Not Classified	288	17.1	0.0	263	65.0
62_1	FERMA PORCI CIUPA	Animal Farms	181	15.0	0.0	99	152.5
45_1	MINA PESCAREASA	Coal Mining	272	14.8	0.0	296	50.0
28_1	UM BASCOV	Other – Not Classified	235	13.9	0.0	121	115.0
79_1	FILATURA MUSCELEANCA SC	Other – Not Classified	203	13.8	0.0	263	52.5
16_1	TRUST POMICOL	Other – Not Classified	232	13.7	0.0	203	67.5
38_2	SC ARO SA	Metal Construction – Small & Machinery	284	13.1	0.0	1,216	10.8
41_1	MINA POENARI	Coal Mining	274	9.9	0.0	181	55.0
1_1	CABANA CUMPANA	Other – Not Classified	306	9.5	0.0	66	144.0
42_1	MINA JUGUR	Coal Mining	274	8.3	0.0	230	36.0
43_1	MINA GODENI	Coal Mining	272	7.7	0.0	181	42.5
59_1	SPITAL CALINESTI	Other – Not Classified	241	4.9	0.0	52	93.7
36_1	SC AGROMEC SA	Other – Not Classified	235	4.1	0.0	66	63.0
23_1	SPITAL VALEA IASULUI	Other – Not Classified	275	3.9	0.0	66	60.0
47_1	MINA SLANIC	Coal Mining	272	3.9	0.0	132	30.0
49_1	MINA BOTENI	Coal Mining	275	3.2	0.0	66	49.0
46_1	MINA BEREVOESTI	Coal Mining	273	3.2	0.0	132	24.0
2_1	COLONIA CAPATINENI	Energy Production	292	2.8	0.0	60	46.5
26_1	UM VALEA URSULUI	Other – Not Classified	242	2.6	0.0	52	49.0
29_1	BAT BASCOV	Petroleum and Gas Extraction	235	2.5	0.0	66	37.5
48_1	MINA ANINOASA	Coal Mining	272	2.5	0.0	99	25.0
3_1	MOTEL CERBURENI	Other – Not Classified	276	2.3	0.0	33	70.0
			Total Loading =	362,433.9	kg/day		

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TABLE 11
CUMULATIVE LOAD OF BOB5 AT km 111

DISCHARGER I.D. No.	DISCHARGER NAME	DESCRIPTION	DISTANCE FROM km 111 (km)	BOD5 LOAD (kg/day)	% OF TOTAL LOAD	DISCHARGE FLOW (cmd)	DISCHARGE BOD5 CONCENTRATION (mg/L)
11_1	RA REGOCOM	Municipal WWTP	113	8826.5	54.9	155,945	56.6
4_1	RA "GOSARG"	Municipal WWTP	155	1746.5	10.9	22,027	79.3
37_1	RA EDILUL	Municipal WWTP	164	1259.7	7.8	22,318	56.4
32_1	SC AUTOMOBILE DACIA SA	Metal Construction – Small & Machinery	126	1146.5	7.1	18,592	61.7
20_3	SC ARPECHIM SA	Oil Refining	111	1029.6	6.4	28,079	36.7
33_1	RA REGOM	Municipal WWTP	127	771.4	4.8	15,427	50.0
58_1	SC VALAHIA	Miscellaneous Food and Beverages	99	202.7	1.3	1,216	166.7
56_1	SGCL TOPOLOVENI	Municipal WWTP	99	150.2	0.9	1,907	78.8
13_3	SC ROLAST SA	Chemical Industry	121	135.9	0.8	5,162	26.3
39_2	SC GRULEN SA	Chemical Industry	169	83.0	0.5	1,660	50.0
10_1	GRUP INDUSTRIAL PETROL	Petroleum and Gas Extraction	140	74.8	0.5	855	87.5
22_1	COMPLEX VINIFICATIE	Miscellaneous Food and Beverages	107	72.6	0.5	726	100.0
44_1	MINA COTESTI	Coal Mining	159	53.8	0.3	181	297.5
34_1	ICN COLIBASI	Other – Not Classified	119	51.6	0.3	811	63.6
8_1	SC BAICULESTI	Miscellaneous Food and Beverages	148	47.7	0.3	726	65.7
12_1	SGCL BASCOV	Municipal WWTP	124	43.8	0.3	690	63.5
18_1	CET GAVANA	Energy Production	121	42.6	0.3	915	46.5
19_1	HIDROCONSTRUCTIA ARGES	Other – Not Classified	119	36.3	0.2	427	85.0
54_1	SC CIMUS SA	Other – Not Classified	174	34.8	0.2	778	44.7
35_1	SGCL MARACINENI	Municipal WWTP	120	33.7	0.2	427	78.8
14_2	SC ROTAN SA	Chemical Industry	123	29.9	0.2	597	50.0
13_2	SC ROLAST SA	Chemical Industry	124	28.0	0.2	1,512	18.5
52_1	SEPPL STILPENI	Other – Not Classified	142	22.4	0.1	395	56.7
25_1	STATIUNEA BRADETU	Other – Not Classified	177	17.1	0.1	263	65.0
45_1	MINA PESCAREASA	Coal Mining	161	14.8	0.1	296	50.0
28_1	UM BASCOV	Other – Not Classified	124	13.9	0.1	121	115.0
16_1	TRUST POMICOL	Other – Not Classified	121	13.7	0.1	203	67.5
38_2	SC ARO SA	Metal Construction – Small & Machinery	173	13.1	0.1	1,216	10.8
41_1	MINA POENARI	Coal Mining	163	9.9	0.1	181	55.0
1_1	CABANA CUMPANA	Other – Not Classified	195	9.5	0.1	66	144.0
42_1	MINA JUGUR	Coal Mining	163	8.3	0.1	230	36.0
43_1	MINA GODENI	Coal Mining	161	7.7	0.0	181	42.5
59_1	SPITAL CALINESTI	Other – Not Classified	130	4.9	0.0	52	93.7
36_1	SC AGROMEC SA	Other – Not Classified	124	4.1	0.0	66	63.0
23_1	SPITAL VALEA IASULUI	Other – Not Classified	164	3.9	0.0	66	60.0
47_1	MINA SLANIC	Coal Mining	161	3.9	0.0	132	30.0
49_1	MINA BOTENI	Coal Mining	164	3.2	0.0	66	49.0
46_1	MINA BEREVOESTI	Coal Mining	162	3.2	0.0	132	24.0
2_1	COLONIA CAPATINENI	Energy Production	181	2.8	0.0	60	46.5
26_1	UM VALEA URSULUI	Other – Not Classified	131	2.6	0.0	52	49.0
29_1	BAT BASCOV	Petroleum and Gas Extraction	124	2.5	0.0	66	37.5
48_1	MINA ANINOASA	Coal Mining	161	2.5	0.0	99	25.0
3_1	MOTEL CERBURENI	Other – Not Classified	165	2.3	0.0	33	70.0
			Total Loading =	16,067.6	kg/day		

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TABLE 12
CUMULATIVE LOAD OF BOB5 AT km 240

DISCHARGER I.D. No.	DISCHARGER NAME	DESCRIPTION	DISTANCE FROM km 240 (km)	BOD5 LOAD (kg/day)	% OF TOTAL LOAD	DISCHARGE FLOW (cmd)	DISCHARGE BOD5 CONCENTRATION (mg/L)
4_1	RA "GOSARG"	Municipal WWTP	155	1746.5	91.9	22,027	79.3
10_1	GRUP INDUSTRIAL PETROL	Petroleum and Gas Extraction	140	74.8	3.9	855	87.5
8_1	SC BAICULESTI	Miscellaneous Food and Beverages	148	47.7	2.5	726	65.7
1_1	CABANA CUMPANA	Other – Not Classified	195	9.5	0.5	66	144.0
2_1	COLONIA CAPATINENI	Energy Production	181	2.8	0.1	60	46.5
3_1	MOTEL CERBURENI	Other – Not Classified	165	2.3	0.1	33	70.0
25_1	STATIUNEA BRADETU	Other – Not Classified	177	17.1	0.9	263	65.0
			Total Loading =	1,900.6	kg/day		

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TABLE B1

DIRECT DISCHARGERS IN THE ARGES BASIN
DESCRIPTION AND LOCATION OF EMISSION

I.D. No.	DISCHARGER NAME	DESCRIPTION OF FACILITY	DISCHARGES TO: RIVER NAME	RIVER KM
1_1	CABANA CUMPANA	Other – Not Classified	Arges	306
2_1	COLONIA CAPATINENI	Energy Production	Arges	292
3_1	MOTEL CERBURENI	Other – Not Classified	Arges	276
6_2	SC BIOTEHNOS SA	Chemical Industry	Arges	266
4_1	RA "GOSARG"	Municipal WWTP	Arges	266
6_1	SC BIOTEHNOS SA	Chemical Industry	Arges	266
8_1	SC BAICULESTI	Miscellaneous Food and Beverages	Arges	259
10_1	GRUP INDUSTRIAL PETROL	Petroleum and Gas Extraction	Arges	251
13_3	SC ROLAST SA	Chemical Industry	Arges	232
18_1	CET GAVANA	Energy Production	Arges	232
16_1	TRUST POMICOL	Other – Not Classified	Arges	232
19_1	HIDROCONSTRUCTIA ARGES	Other – Not Classified	Arges	230
11_1	RA REGOCOM	Municipal WWTP	Arges	224
21_1	CLF STEFANESTI	Miscellaneous Food and Beverages	Arges	223
20_3	SC ARPECHIM SA	Oil Refining	Arges	222
22_1	COMPLEX VINIFICATIE	Miscellaneous Food and Beverages	Arges	218
54_2	SC CIMUS SA	Other – Not Classified	Argesel	45
54_1	SC CIMUS SA	Other – Not Classified	Argesel	44
49_1	MINA BOTENI	Coal Mining	Argesel	34
26_1	UM VALEA URSULUI	Other – Not Classified	Bascov	10
27_1	HAN TURISTIC VALEA URSUL	Other – Not Classified	Bascov	6
12_1	SGCL BASCOV	Municipal WWTP	Bascov	3
29_1	BAT BASCOV	Petroleum and Gas Extraction	Bascov	3
13_2	SC ROLAST SA	Chemical Industry	Bascov	3
28_1	UM BASCOV	Other – Not Classified	Bascov	3
14_2	SC ROTAN SA	Chemical Industry	Bascov	2
15_2	SC ALPROM SA	Other – Not Classified	Bascov	2
46_1	MINA BEREVOESTI	Coal Mining	Bratia	26
47_1	MINA SLANIC	Coal Mining	Bratia	25
48_1	MINA ANINOASA	Coal Mining	Bratia	25
39_2	SC GRULEN SA	Chemical Industry	Bughea	17
43_1	MINA GODENI	Coal Mining	Bughea	9
44_1	MINA COTESTI	Coal Mining	Bughea	7
59_1	SPITAL CALINESTI	Other – Not Classified	Circinov	12
58_1	SC VALAHIA	Miscellaneous Food and Beverages	Circinov	3
56_1	SGCL TOPOLOVENI	Municipal WWTP	Circinov	3
79_1	FILATURA MUSCELEANCA SC	Other – Not Classified	Dimbovita	173
BUCHAREST	BUCHAREST WASTEWATER	Municipal WWTP	Dimbovita	28
64_1	FERMA PORCI BRADU	Animal Farms	Dimbovnic	90
20_1	SC ARPECHIM SA	Oil Refining	Dimbovnic	89
20_2	SC ARPECHIM SA	Oil Refining	Dimbovnic	89
65_1	ROMSUIN TEST OARJA	Animal Farms	Dimbovnic	83
30_1	DISTILARIA DOMNESTI	Miscellaneous Food and Beverages	Doamnei	45
33_1	RA REGOM	Municipal WWTP	Doamnei	10
32_1	SC AUTOMOBILE DACIA SA	Metal Construction – Small & Machinery	Doamnei	9
36_1	SC AGROMEC SA	Other – Not Classified	Doamnei	7
35_1	SGCL MARACINENI	Municipal WWTP	Doamnei	3
34_1	ICN COLIBASI	Other – Not Classified	Doamnei	2
42_1	MINA JUGUR	Coal Mining	Draghici	14
23_1	SPITAL VALEA IASULUI	Other – Not Classified	Iasului	4
24_2	CLF VALEA IASULUI	Miscellaneous Food and Beverages	Iasului	2
62_1	FERMA PORCI CIUPA	Animal Farms	Neajlov	122
41_1	MINA POENARI	Coal Mining	Poenari	4
38_2	SC ARO SA	Metal Construction – Small & Machinery	Tirgului	45
37_1	RA EDILUL	Municipal WWTP	Tirgului	36
45_1	MINA PESCAREASA	Coal Mining	Tirgului	33
51_1	SC MUSCEVIT SA	Miscellaneous Food and Beverages	Tirgului	21
52_1	SEPPL STILPENI	Other – Not Classified	Tirgului	14
53_1	DISTILARIA CLUCEREASA	Miscellaneous Food and Beverages	Tirgului	5
25_1	STATIUNEA BRADETU	Other – Not Classified	Vilsan	41

TABLE B2

DIRECT DISCHARGERS IN THE ARGES BASIN
AVERAGE FLOW AND
CONCENTRATION OF CONTAMINANTS

DISCHARGER I.D.	DISCHARGER NAME	FLOW (cmd)	BOD-5 (mg/L)	COD-mn (mg/L)	TSS (mg/L)	NO3- (mg/L)	CL- (mg/L)	H2S (mg/L)	Oil (mg/L)	Phenols (mg/L)	Fe (mg/L)	Phosphates (mg/L)	Cr+6 (mg/L)	Cu (mg/L)	Zn (mg/L)	Anionic Detergents (mg/L)	pH	Total Solids (mg/L)	NO2- (mg/L)	Cd (mg/L)	Ni (mg/L)	CN (mg/L)	Ca (mg/L)	Mg (mg/L)	Na (mg/L)	NH4+ (mg/L)
1_1	CABANA CUMPANA	66	144	150	84	0.80	46				0.00	0.98				0.09	7.4	540	0.037							24.0
2_1	COLONIA CAPATINENI	60	47	55	38	0.70	14				0.36	1.64				0.15	7.6	365	0.069							3.4
3_1	MOTEL CERBURENI	33	70	65	50	1.55	20		0.0		0.07	0.61				0.17	7.2	160	0.149							0.5
4_1	RA "GOSARG"	22,027	79	100	141	0.97	40	0	0.0	0.001	0.83	0.70	0.00	0.03	0.01	0.28	7.3	521	0.130	0.011	0.00	0.000				8.2
8_1	SC BAICULESTI	726	66	92	120	0.60	50			0.022	0.22	0.36				0.10	7.3	420	0.114			0.000				1.1
10_1	GRUP INDUSTRIAL PETROL	855	88	81	158	0.80	71		0.0		0.13	0.54					7.4	260	0.062							5.0
13_3	SC ROLAST SA	5,162	26	31	51	3.47	173		0.0	0.008	0.11	0.48				0.04	7.1	220	1.142			0.000				0.9
16_1	TRUST POMICOL	203	68	87	122	0.50	23				0.18	1.23					7.2	215	0.003							12.5
18_1	CET GAVANA	915	47	57	49	1.35	272				0.78	0.39					7.0	100	0.028				72.3	18.8	78.6	1.4
19_1	HIDROCONSTRUCTIA ARGES	427	85	87	82	0.80	43		0.0		0.29	0.53	0.00				7.3	180	0.430							8.3
11_1	RA REGOCOM	155,945	57	75	54	0.88	34	0	0.0	0.044	0.33	0.33	0.00	0.01	0.01	0.37	7.0	228	0.409	0.008	0.00	0.002		1.0		4.7
20_3	SC ARPECHIM SA	28,079	37	22	236	1.00	77		0.0	0.040	0.49	0.22				0.06	7.5	350	0.069			0.002				0.4
22_1	COMPLEX VINIFICATIE	726	100	119	192	1.20	14				0.05	0.09					7.0	170	0.050							0.5
54_1	SC CIMUS SA	778	45	58	61	1.33	31		0.0		0.24	1.16				0.00	7.8	327	0.230			0.000				10.8
49_1	MINA BOTENI	66	49	58	220	0.30	48										7.5	340	0.325							7.2
26_1	UM VALEA URSULUI	52	49	77	81	0.70	75				0.40	2.10	0.00			0.25	7.6	230	0.003			0.000				26.1
12_1	SGCL BASCOV	690	64	76	190	0.60	38		0.0	0.014	0.30	2.26	0.00	0.00	0.00	0.59	7.0	273	0.014	0.000	0.00	0.000				7.8
29_1	BAT BASCOV	66	38	75	276	1.10	53		0.0		1.27	0.24				0.24	7.3	1100	0.062							0.6
13_2	SC ROLAST SA	1,512	19	23	60	0.73	31		0.2	0.015	0.14	0.13				0.01	7.3	347	0.010			0.000				0.3
28_1	UM BASCOV	121	115	122	96	0.30	35					3.66	0.00			0.05	7.4	210	0.018			0.000				22.8
14_2	SC ROTAN SA	597	50	81	104	2.00	18			0.000		0.32				0.25	11.6	120	0.031			0.000				0.5
46_1	MINA BEREVOESTI	132	24	30	148	1.90	224					0.36				0.30	7.0	410	0.145							2.7
47_1	MINA SLANIC	132	30	24	304	0.50	66					0.19				0.25	6.9	275	0.041							5.0
48_1	MINA ANINOASA	99	25	51	278	2.60	46					0.63				0.40	7.2	1410	0.390							2.4
39_2	SC GRULEN SA	1,660	60	55	80	0.80	107				1.97	0.07				0.15	6.5	530	0.062						27.9	0.0
43_1	MINA GODENI	181	43	51	136	0.40	71					1.17				0.25	7.6	530	0.106							8.5
44_1	MINA COTESTI	181	298	440	330	1.10	28					0.65				0.30	7.0	510	0.390							11.9
59_1	SPITAL CALINESTI	52	94	103	173	0.30	49		0.0	0.018	0.00	2.63				0.69	7.5	560	0.029			0.000				8.4
58_1	SC VALAHIA	1,216	167	184	148	0.53	49				2.86	0.59				0.20	6.3	513	0.058							5.7
56_1	SGCL TOPOLOVENI	1,907	79	93	258	0.70	73		0.0	0.011	0.17	1.18	0.00	0.00	0.01	0.36	7.8	521	0.078	0.061	0.00	0.005				8.9
79_1	FILATURA MUSCELEANCA SC	263	53	70	351	3.35	35		0.0	0.008	0.13	0.21	0.05			0.29	7.6	563	0.214							0.4
BUCHAREST	BUCHAREST WASTEWATER	1,710,000	165		331																					
64_1	FERMA PORCI BRADU	296	304	395	840	1.30	227			0.555	1.65	14.60					6.3	1765	0.954							300.0
20_1	SC ARPECHIM SA	47,721	33	38	73	1.07	127		15.3	0.146	1.06	0.26				0.17	7.8	480	0.520			0.024				21.7
65_1	ROMSUIN TEST OARJA	395	820	887	1846	3.20	1030			0.520	0.18	10.20					7.0	2315	0.081							156.0
33_1	RA REGOM	15,427	50	63	104	0.48	39		0.0	0.000	0.28	1.20	0.00	0.00	0.01	0.34	7.2	326	0.077	0.001	0.00	0.000				3.9
32_1	SC AUTOMOBILE DACIA SA	18,592	62	80	191	1.40	102		0.0	0.000	0.49	1.64	0.00	0.27	0.01		7.1	297	0.190	0.016	0.00	0.000				4.0
36_1	SC AGROMEC SA	66	63	79	164	0.60	27		1.0		0.13	1.18					7.4	195	0.165			0.000				5.1
35_1	SGCL MARACINENI	427	79	97	136	0.95	30		0.0	0.000	0.45	0.73	0.00	0.00	0.00	1.52	7.6	543	0.233	0.002	0.00	0.000				4.6
34_1	ICN COLIBASI	811	64	69	68	2.84	35		0.0		0.14	0.84	0.00	0.01	0.00	0.07	7.5	288	0.168	0.002	0.00	0.000				2.8
42_1	MINA JUGUR	230	36	59	220	0.30	46					1.06				0.25	7.4	385	0.013							9.1
23_1	SPITAL VALEA IASULUI	66	60	63	116	0.70	76				0.49	0.49				0.36	7.7	345	0.015			0.000				1.9
62_1	FERMA PORCI CIUPA	99	153	174	694	0.60	557			0.470	0.22	12.65					7.6	2025	0.190							70.2
41_1	MINA POENARI	181	55	87	114	0.72	217					0.90				0.30	7.5	260	0.043							8.9
38_2	SC ARO SA	1,216	11	17	41	2.35	57		0.5		0.11	0.34	0.01	0.00	0.01	0.00	7.2	246	0.117	0.001	0.00	0.000				0.9
37_1	RA EDILUL	22,318	56	74	161	0.96	35	0	0.0	0.007	0.31	1.07	0.00	0.02	0.01	0.31	7.0	448	0.226	0.003	0.00	0.000				8.4
45_1	MINA PESCAREASA	296	50	91	364	0.40	18					0.41				0.25	7.0	840	0.200							1.8
52_1	SEPPL STILPENI	395	57	75	152	0.53	151		0.0	0.078	0.09	3.63	0.00			0.25	7.7	433	0.039							14.6
25_1	STATIUNEA BRADETU	263	65	79	129	0.33	89			0.022	0.22	1.50				0.22	7.5	297	0.120							11.7

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TABLE B3

DIRECT DISCHARGERS IN THE ARGES BASIN
AVERAGE CONTAMINANT LOADING

DISCHARGER I.D.	DISCHARGER NAME	FLOW (cmd)	BOD-5 (kg/day)	COD-mn (kg/day)	TSS (kg/day)	NO3- (kg/day)	CL- (kg/day)	H2S (kg/day)	Oil (kg/day)	Phenols (kg/day)	Fe (kg/day)	Phosphate (kg/day)	Cr+6 (kg/day)	Cu (kg/day)	Zn (kg/day)	Detergent (kg/day)	Solids (kg/day)	NO2- (kg/day)	Cd (kg/day)	Ni (kg/day)	CN (kg/day)	Ca (kg/day)	Mg (kg/day)	Na (kg/day)	NH4+ (kg/day)
1_1	CABANA CUMPANA	66	9	10	6	0.1	3					0.1				0.0	36	0.0							1.6
2_1	COLONIA CAPATINENI	60	3	3	2	0.0	1				0.0	0.1				0.0	23	0.0							0.2
3_1	MOTEL CERBURENI	33	2	3	2	0.1	1				0.0	0.0				0.0	5	0.0							0.0
4_1	RA "GOSARG"	22,027	1,746	2,212	3,109	21.4	880			0.0	18.3	15.5		0.6	0.2	6.2	11,486	2.9	0.2						135.9
8_1	SC BAICULESTI	726	48	67	87	0.4	36			0.0	0.2	0.3				0.1	305	0.1							0.8
10_1	GRUP INDUSTRIAL PETROL	855	75	69	135	0.7	61				0.1	0.5					239	0.1							4.3
13_3	SC ROLAST SA	5,162	136	158	262	17.9	892			0.0	0.6	2.5				0.2	1,136	5.9							4.5
16_1	TRUST POMICOL	203	14	18	25	0.1	5				0.0	0.2					44	0.0							2.5
18_1	CET GAVANA	915	43	52	45	1.2	249				0.7	0.4					92	0.0				66.2	17.2	70.1	1.3
19_1	HIDROCONSTRUCTIA ARGES	427	36	37	35	0.3	18				0.1	0.2					77	0.2							3.5
11_1	RA REGOCOM	155,945	8,826	11,702	8,359	137.2	5,311			6.8	51.5	51.1		1.9	1.6	57.2	35,556	63.8	0.9		0.3		155.9		736.1
20_3	SC ARPECHIM SA	26,079	1,030	621	6,627	26.1	2,159			1.1	13.7	6.1				1.6	9,828	1.9			0.1				12.2
22_1	COMPLEX VINIFICATIE	726	73	86	139	0.9	10				0.0	0.1					123	0.0							0.4
54_1	SC CIMUS SA	778	35	45	48	1.0	24				0.2	0.9					254	0.2							8.3
49_1	MINA BOTENI	66	3	4	14	0.0	3										22	0.0							0.5
26_1	UM VALEA URSULUI	52	3	4	4	0.0	4				0.0	0.1				0.0	12	0.0							1.4
12_1	SGCL BASCOV	690	44	52	131	0.4	26			0.0	0.2	1.6		0.0	0.0	0.4	186	0.0							5.4
29_1	BAT BASCOV	66	2	5	18	0.1	3				0.1	0.0				0.0	72	0.0							0.0
13_2	SC ROLAST SA	1,512	26	34	91	1.1	47		0.2	0.0	0.2	0.2				0.0	524	0.0							0.4
28_1	UM BASCOV	121	14	15	12	0.0	4					0.4				0.0	25	0.0							2.7
14_2	SC ROTAN SA	597	30	31	62	1.2	11			0.0		0.2				0.1	72	0.0							0.3
46_1	MINA BEREVOESTI	132	3	4	19	0.2	29					0.0				0.0	54	0.0							0.4
47_1	MINA SLANIC	132	4	3	40	0.1	9					0.0				0.0	38	0.0							0.7
48_1	MINA ANINOASA	99	2	5	27	0.3	5					0.1				0.0	139	0.0							0.2
39_2	SC GRULEN SA	1,660	83	92	133	1.3	177				3.3	0.1				0.2	880	0.1						46.3	
43_1	MINA GODENI	181	8	9	25	0.1	13					0.2				0.0	96	0.0							1.5
44_1	MINA COTESTI	181	54	80	60	0.2	5					0.2				0.1	92	0.1							2.1
59_1	SPITAL CALINESTI	52	5	5	9	0.0	3			0.0		0.1				0.0	29	0.0							0.4
58_1	SC VALAHIA	1,216	203	224	180	0.6	59				3.5	0.7				0.2	624	0.1							6.9
56_1	SGCL TOPOLOVENI	1,907	150	177	492	1.3	139			0.0	0.3	2.2		0.0	0.0	0.7	993	0.1	0.1		0.0				16.9
79_1	FILATURA MUSCELEANCA SC	263	14	18	92	0.9	9			0.0	0.0	0.1	0.0			0.1	148	0.1							0.1
BUCHAREST	BUCHAREST WASTEWATER	1,710,000	282,150		566,010																				
64_1	FERMA PORCI BRADU	296	90	117	249	0.4	67			0.2	0.5	4.3					526	0.3							88.8
20_1	SC ARPECHIM SA	47,721	1,559	1,820	3,500	50.9	6,046		731.7	7.0	50.4	12.2				7.9	22,906	24.8			1.2				1,035.5
65_1	ROMSUIN TEST OARJA	395	324	350	728	1.3	406			0.2	0.1	4.0					913	0.0							61.5
33_1	RA REGOM	15,427	771	979	1,598	7.4	601				4.0	16.5		0.0	0.1	5.2	5,029	1.2	0.0						60.2
32_1	SC AUTOMOBILE DACIA SA	18,592	1,146	1,494	3,545	26.0	1,892				9.1	30.6		5.0	0.2		5,516	3.5	0.3						75.0
36_1	SC AGROMEC SA	66	4	5	11	0.0	2		0.1		0.0	0.1					13	0.0							0.3
35_1	SGCL MARACINENI	427	34	41	58	0.4	13				0.2	0.3		0.0		0.6	232	0.1	0.0						2.0
34_1	ICN COLIBASI	611	52	56	55	2.3	26				0.1	0.7		0.0		0.1	234	0.1	0.0						2.3
42_1	MINA JUGUR	230	8	14	51	0.1	11					0.2				0.1	89	0.0							2.1
23_1	SPITAL VALEA IASULUI	66	4	5	8	0.0	5				0.0	0.0				0.0	23	0.0							0.1
62_1	FERMA PORCI CIUPA	99	15	17	68	0.1	55			0.0	0.0	1.2					200	0.0							6.9
41_1	MINA POENARI	181	10	18	21	0.1	39					0.2				0.1	47	0.0							1.6
38_2	SC ARO SA	1,216	13	20	50	2.9	69		0.6		0.1	0.4	0.0	0.0	0.0	0.0	299	0.1	0.0						1.1
37_1	RA EDILUL	22,318	1,260	1,661	3,591	21.3	783			0.2	7.0	23.9		0.3	0.2	6.9	9,993	5.0	0.1						141.8
45_1	MINA PESCAREASA	296	15	27	108	0.1	5					0.1				0.1	249	0.1							0.5
52_1	SEPPL STILPENI	395	22	30	60	0.2	60			0.0	0.0	1.4				0.1	171	0.0							5.8
25_1	STATIUNEA BRADETU	263	17	21	34	0.1	23			0.0	0.1	0.4				0.1	78	0.0							3.1
	total	2,043,726	300,219	22,517	600,032	331	20,300		733	16	165	183	0	8	2	88	109,726	111	2		1	66	173	116	2,440

TABLE B4

DIRECT DISCHARGERS IN THE ARGES BASIN
PERCENTAGE CONTAMINANT LOADING

DISCHARGER I.D.	DISCHARGER NAME	FLOW (%)	BOD-5 (%)	COD-mn (%)	TSS (%)	NO3- (%)	CL- (%)	H2S (%)	Oil (%)	Phenols (%)	Fe (%)	Phosphate (%)	Cr+6 (%)	Cu (%)	Zn (%)	Detergent (%)	Solids (%)	NO2- (%)	Cd (%)	Ni (%)	CN (%)	Ca (%)	Mg (%)	Na (%)	NH4+ (%)
1_1	CABANA CUMPANA	0.0	0.0	0.0	0.0	0.0	0.0					0.0				0.0	0.0	0.0							0.1
2_1	COLONIA CAPATINENI	0.0	0.0	0.0	0.0	0.0	0.0				0.0	0.1				0.0	0.0	0.0							0.0
3_1	MOTEL CERBURENI	0.0	0.0	0.0	0.0	0.0	0.0				0.0	0.0				0.0	0.0	0.0							0.0
4_1	RA "GOSARG"	1.1	0.6	9.8	0.5	6.5	4.3			0.2	11.1	8.5		6.0	7.6	7.0	10.5	2.6	14.9						5.6
8_1	SC BAICULESTI	0.0	0.0	0.3	0.0	0.1	0.2			0.1	0.1	0.1				0.1	0.3	0.1							0.0
10_1	GRUP INDUSTRIAL PETROL	0.0	0.0	0.3	0.0	0.2	0.3				0.1	0.3					0.2	0.0							0.2
13_3	SC ROLAST SA	0.3	0.0	0.7	0.0	5.4	4.4			0.3	0.3	1.4				0.2	1.0	5.3							0.2
16_1	TRUST POMICOL	0.0	0.0	0.1	0.0	0.0	0.0				0.0	0.1					0.0	0.0							0.1
18_1	CET GAVANA	0.0	0.0	0.2	0.0	0.4	1.2				0.4	0.2					0.1	0.0				100.0	9.9	60.2	0.1
19_1	HIDROCONSTRUCTIA ARGES	0.0	0.0	0.2	0.0	0.1	0.1				0.1	0.1					0.1	0.2							0.1
11_1	RA REGOCOM	7.6	2.9	52.0	1.4	41.5	26.2			43.4	31.3	28.0		23.5	70.6	64.7	32.4	57.4	55.7		18.2		90.1		30.2
20_3	SC ARPECHIM SA	1.4	0.3	2.8	1.1	8.5	10.6			7.1	8.3	3.3				1.6	9.0	1.7			3.4				0.5
22_1	COMPLEX VINIFICATIE	0.0	0.0	0.4	0.0	0.3	0.1				0.0	0.0					0.1	0.0							0.0
54_1	SC CIMUS SA	0.0	0.0	0.2	0.0	0.3	0.1				0.1	0.5					0.2	0.2							0.3
49_1	MINA BOTENI	0.0	0.0	0.0	0.0	0.0	0.0										0.0	0.0							0.0
26_1	UM VALEA URSULUI	0.0	0.0	0.0	0.0	0.0	0.0				0.0	0.1				0.0	0.0	0.0							0.1
12_1	SGCL BASCOV	0.0	0.0	0.2	0.0	0.1	0.1			0.1	0.1	0.9		0.0	0.0	0.5	0.2	0.0							0.2
29_1	BAT BASCOV	0.0	0.0	0.0	0.0	0.0	0.0				0.1	0.0				0.0	0.1	0.0							0.0
13_2	SC ROLAST SA	0.1	0.0	0.2	0.0	0.3	0.2		0.0	0.1	0.1	0.1				0.0	0.5	0.0							0.0
28_1	UM BASCOV	0.0	0.0	0.1	0.0	0.0	0.0					0.2				0.0	0.0	0.0							0.1
14_2	SC ROTAN SA	0.0	0.0	0.1	0.0	0.4	0.1			0.0		0.1				0.2	0.1	0.0							0.0
46_1	MINA BEREVOESTI	0.0	0.0	0.0	0.0	0.1	0.1					0.0				0.0	0.0	0.0							0.0
47_1	MINA SLANIC	0.0	0.0	0.0	0.0	0.0	0.0					0.0				0.0	0.0	0.0							0.0
48_1	MINA ANINOASA	0.0	0.0	0.0	0.0	0.1	0.0					0.0				0.0	0.1	0.0							0.0
39_2	SC GRULEN SA	0.1	0.0	0.4	0.0	0.4	0.9				2.0	0.1				0.3	0.8	0.1						39.8	
43_1	MINA GODENI	0.0	0.0	0.0	0.0	0.0	0.1					0.1				0.1	0.1	0.0							0.1
44_1	MINA COTESTI	0.0	0.0	0.4	0.0	0.1	0.0					0.1				0.1	0.1	0.1							0.1
59_1	SPITAL CALINESTI	0.0	0.0	0.0	0.0	0.0	0.0			0.0		0.1				0.0	0.0	0.0							0.0
58_1	SC VALAHIA	0.1	0.1	1.0	0.0	0.2	0.3				2.1	0.4				0.3	0.6	0.1							0.3
56_1	SGCL TOPOLOVENI	0.1	0.1	0.8	0.1	0.4	0.7			0.1	0.2	1.2		0.1	0.8	0.8	0.9	0.1	6.0		0.7				0.7
79_1	FILATURA MUSCELEANCA SC	0.0	0.0	0.1	0.0	0.3	0.0			0.0	0.0	0.0	66.7			0.1	0.1	0.1							0.0
BUCHAREST	BUCHAREST WASTEWATER	83.7	94.0		94.3																				
64_1	FERMA PORCI BRADU	0.0	0.0	0.5	0.0	0.1	0.3			1.1	0.3	2.4					0.5	0.3							3.6
20_1	SC ARPECHIM SA	2.3	0.5	8.1	0.6	15.4	29.8		99.9	44.6	30.6	6.7				8.9	20.9	22.3			77.7				42.4
65_1	ROMSUIN TEST OARJA	0.0	0.1	1.6	0.1	0.4	2.0			1.3	0.0	2.2					0.8	0.0							2.5
33_1	RA REGOM	0.6	0.3	4.3	0.3	2.2	3.0				2.4	10.1		0.4	4.1	5.9	4.6	1.1	0.5						2.5
32_1	SC AUTOMOBILE DACIA SA	0.9	0.4	6.6	0.6	7.9	9.3				5.5	16.7		63.5	7.4		5.0	3.2	18.0						3.1
36_1	SC AGROMEC SA	0.0	0.0	0.0	0.0	0.0	0.0		0.0		0.0	0.0					0.0	0.0							0.0
35_1	SGCL MARACINENI	0.0	0.0	0.2	0.0	0.1	0.1				0.1	0.2		0.0		0.7	0.2	0.1	0.0						0.1
34_1	ICN COLIBASI	0.0	0.0	0.2	0.0	0.7	0.1				0.1	0.4		0.1		0.1	0.2	0.1	0.1						0.1
42_1	MINA JUGUR	0.0	0.0	0.1	0.0	0.0	0.1					0.1				0.1	0.1	0.0							0.1
23_1	SPITAL VALEA IASULUI	0.0	0.0	0.0	0.0	0.0	0.0				0.0	0.0				0.0	0.0	0.0							0.0
62_1	FERMA PORCI CIUPA	0.0	0.0	0.1	0.0	0.0	0.3			0.3	0.0	0.7					0.2	0.0							0.3
41_1	MINA POENARI	0.0	0.0	0.1	0.0	0.0	0.2					0.1				0.1	0.0	0.0							0.1
38_2	SC ARO SA	0.1	0.0	0.1	0.0	0.9	0.3		0.1		0.1	0.2	33.3	0.1	0.7	0.0	0.3	0.1	0.1						0.0
37_1	RA EDILUL	1.1	0.4	7.4	0.6	6.4	3.9			1.1	4.2	13.1		4.3	8.5	7.8	9.1	4.5	4.6						5.8
45_1	MINA PESCAREASA	0.0	0.0	0.1	0.0	0.0	0.0					0.1				0.1	0.2	0.1							0.0
52_1	SEPPL STILPENI	0.0	0.0	0.1	0.0	0.1	0.3			0.2	0.0	0.8				0.1	0.2	0.0							0.2
25_1	STATIUNEA BRADETU	0.0	0.0	0.1	0.0	0.0	0.1			0.0	0.0	0.2				0.1	0.1	0.0							0.1

TABLE B5

INDIRECT DISCHARGERS IN THE ARGES BASIN
AVERAGE FLOW AND
CONCENTRATION OF CONTAMINANTS

DISCHARGER I.D.	DISCHARGER NAME	FLOW (cmd)	BOD-5 (mg/L)	COD-mn (mg/L)	COD-cr (mg/L)	TSS (mg/L)	NO3- (mg/L)	CL- (mg/L)	H2S (mg/L)	Oil (mg/L)	Phenols (mg/L)	Fe (mg/L)	Phosphates (mg/L)	Cr+6 (mg/L)	Cu (mg/L)	Zn (mg/L)	Anionic Detergents (mg/L)	pH	Total Solids (mg/L)	NO2- (mg/L)	Cd (mg/L)	Ni (mg/L)	CN (mg/L)	Ca (mg/L)	Mg (mg/L)	Na (mg/L)	NH4+ (mg/L)	data source
to Pitesti STP:																												
15_1	ALPROM	4,320	800		3660	1892	3.40					0.44	0.30														22.1	albu
14_1	ROTAN	1,397	347	976		128	2.40				0.002		4.39					4.6	1100	0.180							144.0	icim
	NOVATEX	4,320	76		1600	200	2.00					0.35	0.31														49.0	albu
	DIVERTEX	2,592	125		76	100	0.24						4.80														3.6	albu
	ARGESANA	3,456	145		1240	60	0.20					0.04	0.24														14.0	albu
13_1	ROLAST	1,052	33	63		172	0.80	26					0.12					6.9	172	0.076							3.0	icim
	CET GAVANA	346	16	24		12	1.80	21				0.13	0.12					6.6	110	0.006							0.1	albu
17_1	PITBERE	259	980	1023		3004	1.20	57				0.70	68.30					4.3	7470	0.037							1.7	albu
	MORARIT	66	122	142		160	0.80	60					2.92					8.4	190	0.175							30.0	albu
	FRIGORIFER		68		180	210																						albu
	PROGRESUL	173	65	79		520	7.60	53				0.08	0.61					8.3	200	0.125							18.5	albu
	MOTOARE ELECT.	259	13	26		192	1.00	43				0.40		0.03				8.4	390	0.037	0.001		0.009					albu
	ICIL		130		680	177																						albu
	IPMPB	1,728	55	71		20	0.40	18				0.58	0.34		0.00				70	0.100	0.003						0.1	albu
	ABATOR	432	65	79		80	1.80	89				0.09	0.73					6.5	230	0.025							12.0	albu
	SOPRON	346	60	67		100	0.40	28					0.24					8.1	310	0.080							0.1	albu
to Cimpulung STP:																												
38_1	ARO	8,640	55	78		258	0.50	49							0.01	0.00	0.16			0.294							7.4	albu
39_1	GRULEN	2,458	137	182		751	1.20	106				0.49	0.24				0.37	6.5	1143	0.015						68.1	5.5	icim
	CHERESTEA VOINES	259	272	284		393	0.50	78			0.024						0.10			0.125							29.4	albu
	AUTOBAZA	156	61	69		129	0.91	22									0.02			0.116							0.4	albu
	TABACARIA	173	233	298		434	1.40	469												0.147							7.8	albu
to Curtea de Arges STP:																												
5_1	ABATOR PASARI	691	130	144		168	0.30	44					1.21				0.21	6.7	400	0.034							3.5	albu/icim
	ARPO	1,356	67	82		142	1.51	11												0.273							14.0	albu
	UFET	259	183	208		100	1.67	17												0.023							0.6	albu
	ELECTROARGES	2,160	110	115		94	0.84	36												0.084							3.0	albu
	CONFARG	605	75	71		258	0.60	28												0.200							0.4	albu
	ICIL	259	1750	1935		212	110.00	11573									0.31	3.9	680	0.063							1.4	albu

TABLE B6

INDIRECT DISCHARGERS IN THE ARGES BASIN
AVERAGE CONTAMINANT LOADING TO STP

DISCHARGER I.D.	DISCHARGER NAME	FLOW (cmd)	BOD-5 (kg/day)	COD-mn (kg/day)	COD-cr (kg/day)	TSS (kg/day)	NO3- (kg/day)	CL- (kg/day)	H2S (kg/day)	Oil (kg/day)	Phenols (kg/day)	Fe (kg/day)	Phosphates (kg/day)	Cr+6 (kg/day)	Cu (kg/day)	Zn (kg/day)	Anionic Detergents (kg/day)	Total Solids (kg/day)	NO2- (kg/day)	Cd (kg/day)	Ni (kg/day)	CN (kg/day)	Ca kg/day	Mg kg/day	Na kg/day	NH4+ (kg/day)
to Pitesti STP:																										
15_1	ALPROM	4,320	3,456		15,811	8,173	14.7					1.9	1.3													95.3
14_1	ROTAN	1,397	485	1,363		179	3.4				0.0		6.1					1,537	0.3							201.2
	NOVATEX	4,320	324		6,912	864	8.6					1.5	1.3													211.7
	DIVERTEX	2,592	324		194	259	0.6						12.4													9.3
	ARGESANA	3,456	501		4,265	207	0.7					0.2	0.8													48.5
13_1	ROLAST	1,052	35	66		181	0.8	26					0.1					181	0.1							3.2
	CET GAVANA	346	5	8		4	0.6	7				0.0	0.0					38	0.0							0.0
17_1	PITBERE	259	228	265		779	0.3	15				0.2	17.7					1,936	0.0							0.4
	MORARIT	86	11	12		14	0.1	5					0.3					16	0.0							2.6
	FRIGORIFER																									
	PROGRESUL	173	11	14		90	1.3	9				0.0	0.1					35	0.0							3.2
	MOTOARE ELECT.	259	3	7		50	0.3	11				0.1		0.0				101	0.0	0.0		0.0				
	ICIL																									
	IPMPB	1,728	95	123		35	0.7	31				1.0	0.6		0.0			121	0.2	0.0						0.1
	ABATOR	432	28	34		35	0.8	38				0.0	0.3					99	0.0							5.2
	SOPRON	346	21	23		35	0.1	10					0.1					107	0.0							0.0
	total	20,766	5,527	1,917	27,203	10,904	33	152			0	5	41	0	0			4,171	1	0		0				581
to Cimpulung STP:																										
38_1	ARO	8,640	475	672		2,229	4.3	419							0.1	0.0	1.4		2.5							63.8
39_1	GRULEN	2,458	337	447		1,845	2.9	265				1.2	0.6				0.9	2,809	0.0						167.4	13.4
	CHERESTEA VOINES	259	70	74		102	0.1	20			0.0						0.0		0.0							7.6
	AUTOBAZA	156	10	11		20	0.1	3									0.0		0.0							0.1
	TABACARIA	173	40	52		75	0.2	81											0.0							1.3
	total	11,686	932	1,255		4,271	8	788			0	1	1		0	0	2	2,809	3						167	86
to Curtea de Arges STP:																										
5_1	ABATOR PASARI	691	90	100		116	0.2	31					0.8				0.1	276	0.0							2.4
	ARPO	1,356	91	111		193	2.0	15											0.4							19.0
	UFET	259	47	54		26	0.4	4											0.0							0.2
	ELECTROARGES	2,160	237	247		204	1.8	77											0.2							6.5
	CONFARG	605	45	43		156	0.4	17											0.1							0.2
	ICIL	259	454	502		55	28.5	3,000									0.1	176	0.0							0.4
	total	5,331	964	1,057		750	33	3,143					1				0	453	1							29

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TABLE B7

INDIRECT DISCHARGERS IN THE ARGES BASIN
PERCENTAGE CONTAMINANT LOADING TO STP

DISCHARGER I.D.	DISCHARGER NAME	FLOW (%)	BOD-5 (%)	COD-mn	COD-cr (%)	TSS (%)	NO3- (%)	CL- (%)	H2S (%)	Oil (%)	Phenols (%)	Fe (%)	Phosphates (%)	Cr+6 (%)	Cu (%)	Zn (%)	Anionic Detergents (%)	Total Solids (%)	NO2- (%)	Cd (%)	Ni (%)	CN (%)	Ca (%)	Mg (%)	Na (%)	NH4+ (%)
15_1	ALPROM	20.8	62.5		58.1	75.0	44.5					38.4	3.1													16.4
14_1	ROTAN	6.7	8.6	71.1		1.6	10.2				100.0		14.9					36.8	41.9							34.6
	NOVATEX	20.8	5.9		25.4	7.9	26.2					30.5	3.2													36.5
	DIVERTEX	12.5	5.9		0.7	2.4	1.9						30.2													1.6
	ARGESANA	16.6	9.1		15.8	1.9	2.1					3.1	2.0													8.4
13_1	ROLAST	5.1	0.6	3.5		1.7	2.5	17.1					0.3					4.3	13.2							0.5
	CET GAVANA	1.7	0.1	0.4		0.0	1.9	4.8				0.9	0.1					0.9	0.4							0.0
17_1	PITBERE	1.2	4.1	13.8		7.1	0.9	9.7				3.7	42.9					46.4	1.6							0.1
	MORARIT	0.4	0.2	0.6		0.1	0.2	3.4					0.6					0.4	2.5							0.4
	FRIGORIFER																									
	PROGRESUL	0.8	0.2	0.7		0.8	4.0	6.0				0.3	0.3					0.8	3.6							0.6
	MOTOARE ELECT.	1.2	0.1	0.4		0.5	0.8	7.2				2.1						2.4	1.6							
	ICIL																									
	IPMPB	8.3	1.7	6.4		0.3	2.1	20.1				20.2	1.4					2.9	28.8							0.0
	ABATOR	2.1	0.5	1.8		0.3	2.4	25.2				0.8	0.8					2.4	1.8							0.9
	SOPRON	1.7	0.4	1.2		0.3	0.4	8.4					0.2					2.6	4.6							0.0
to Cimpulung STP:																										
38_1	ARO	73.9	51.0	53.5		52.2	55.5	53.1							100.0	100.0	60.3		95.8							74.0
39_1	GRULEN	21.0	36.1	35.6		43.2	37.9	33.6				100.0	100.0				38.4	100.0	1.4						100.0	15.6
	CHERESTEA VOINES	2.2	7.5	5.9		2.4	1.7	2.6			100.0						1.1		1.2							8.8
	AUTOBAZA	1.3	1.0	0.9		0.5	1.8	0.4									0.2		0.7							0.1
	TABACARIA	1.5	4.3	4.1		1.8	3.1	10.3											1.0							1.6
to Curtea de Arges STP:																										
5_1	ABATOR PASARI	13.0	9.3	9.4		15.5	0.6	1.0					100.0				63.8	61.1	3.3							8.4
	ARPO	25.4	9.5	10.5		25.7	8.1	0.5											51.6							66.2
	UFET	4.9	4.9	5.1		3.5	1.3	0.1											0.8							0.7
	ELECTROARGES	40.5	24.6	23.4		27.2	5.4	2.4											25.2							22.6
	CONFARG	11.3	4.7	4.1		20.8	1.1	0.5											16.9							0.8
	ICIL	4.9	47.1	47.5		7.3	85.4	95.4									36.2	38.9	2.3							1.3